ILLUMINATING ENGINEERING

NOVEMBER, 1949

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Metal Reflector Coatings for Filament Lamps
The I.E.S.—A Review and a Challenge
Brightnesses in Visual Field
Low Pressure Mercury Discharges
Laundry Lighting Requirements
Lighting for Flour Mills

PUBLISHED BY THE ILLUMINATING ENGINEERING SOCIETY

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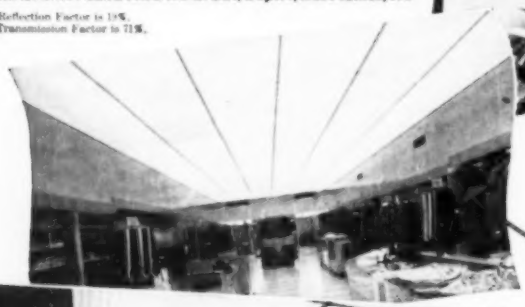

Illustration left—Wright Clothing Store, Greensboro, N. C. Designer and Contractor: Starr Electric Co., Greensboro, N. C.

Stetson Shoe Store, Pittsburgh, Pa.: *Shoe Store Sales Area. John Schurke, Pittsburgh, Designer; Wood Electric Construction Co., Pittsburgh, Electrical Contractor.*

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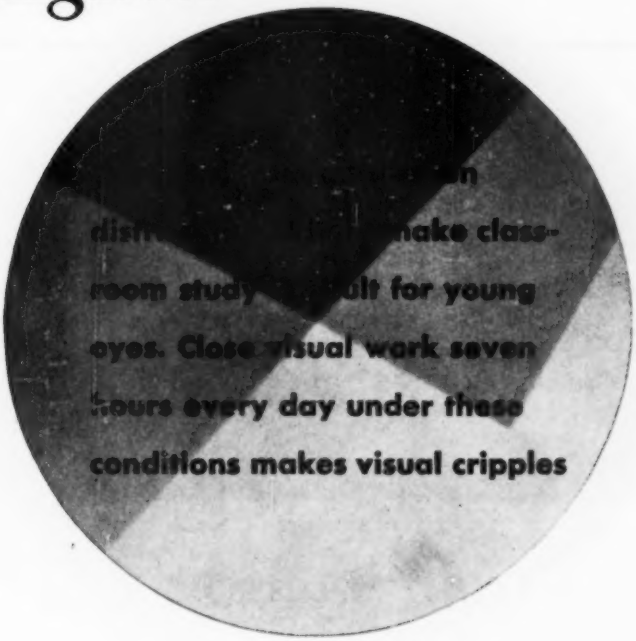

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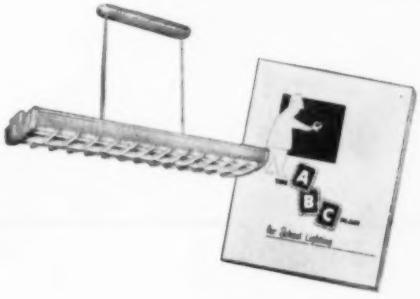

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ILLUMINATING ENGINEERING

THE JOURNAL OF THE ILLUMINATING ENGINEERING SOCIETY

NOVEMBER
1949

Vol. XLIV
No. 11

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Charles H. Goddard, President, 1949-1950

Illuminating Engineering Society

CHARLES H. GODDARD, the Society's 45th President, personifies the trend notable in I.E.S., to young vigorous leadership. His qualifications to assume this leadership were recognized early in his association in the Society. Active from the first on national committees, Mr. Goddard was also an exceptionally active worker for his local Section, serving on numerous committees, Board of Managers and as an officer of the Pittsburgh Section where his business connections transferred him from New York. So outstanding were his contributions that within five years of his election to membership, he was elected to the important office of Regional Vice-President and was appointed a Director of the Society three years later.

The Society's strength lies in the devotion of its officers, committees and members to its basic aims. In all of these—as member, active committee worker and officer — Mr. Goddard has demonstrated a sound, enthusiastic approach, from which the Society has benefited in many ways. It is significant that one of the "planks" of his "Paltform Speech" given before the National Technical Conference at French Lick, is his determination during his term of office, to bring to each member a complete realization of what the Illuminating Engineering Society has to offer, and how best to make these offerings.

President Goddard's qualifications for executive leadership are equally apparent in his business career. Entering the lighting industry in 1929 with the Lighting Bureau of the Columbus Railway Power and Light Company, joined the Pittsburgh Reflector Co. as an applications engineer, moving progressively to salesman, Division Sales Manager, General Sales Manager, and to Vice-President and Director of Sales of the company at the age of 35. His present position is Manager of Utility Sales for Sylvania Electric Products Inc., which company he joined in 1944.

While his work has been identified with the lighting industry, Charlie Goddard brings to the Society a vast fund of knowledge in all phases of business, garnered from study and experience in many diversified aspects of its operation.

The I. E. S.— A Review and a Challenge

By WARD HARRISON
1949 I.E.S. Gold Medallist

"It is a proper characteristic of a Professional Society to reward its members for merit in the profession as well as contributions by the membership in the administration of Society affairs." Doctor Harrison received the Society's 1949 Gold Medal at French Lick. His response is presented here, that all who will may profit by his observations.

I CHOSE as my subject the Illuminating Engineering Society, not to discuss it from the standpoint of its membership and finances, or of this year's accomplishment and next year's problems — rather, I would like to talk about the Society in a considerably more general way.

To begin at the beginning, it was organized in 1906, when I happened to be a freshman in Engineering School, so that its career and my own experience in engineering have run almost concurrently. It has spanned nearly the entire era during which the world has been able to generate light efficiently enough and conveniently enough to make specialization in illuminating engineering practicable for any considerable number of people.

The year 1906 may be difficult, if not impossible, for some of you to look back to. However, that was the time of the San Francisco fire; the time when Teddy Roosevelt was President of the U.S.A.; when the Russo-Japanese War had just been ended; when Oklahoma was admitted as a state; and the year in which Bakelite, the forerunner of our present translucent plastics, was invented. It was a time, too, when only one person in a thousand in this country had an automobile; and when by contrast the electrical industry in the U.S.A. was 27 years old and considered quite mature — big business, in fact, with sales of 3 billion kilowatt hours for lighting alone bringing in some $150,000,000 a year, to say nothing of the 46 million lamps consumed annually.

What has taken place in the intervening forty-odd years?

1. The sale of electric lamps for use on general lighting circuits has increased just 20 times — to nearly one billion.
2. The use of kilowatt hours for lighting has increased 25 times — to seventy-five billion.
3. The use of light itself, which we measure in billions and trillions of lumen-hours, has increased 150 times after making due allowance for gas and kerosene previously consumed; that is, it has doubled every five or six years on the average since 1906, and is still doing it.

Gloomy Predictions?

It is true that back in 1938 there were gloomy predictions by some as to the effect of the advent of the fluorescent lamp on the future of the industry. Ten years have passed. What is the record? The kilowatt hours employed for lighting has increased to 2½ times the 1938 level, the amount of light used annually in the U.S.A. has increased to 3½ times; the lighting fixture business has grown into the half-billion-dollar class—all in this decade. There is nothing more insatiable than people's desire for more light. I think I have mentioned upon previous occasions that in the severe depression of the '30's the people of the United States economized on luxuries (kid gloves and the like) 40 per cent,

on tonnage of food 10 per cent, on gasoline 5 per cent, but on their own lighting not at all.

We might also stop to review the history of miniature lamps, a business of no consequence in 1906; less than a million produced as against 500 million for 1948. Think of the indispensable services these lamps render in airplanes, automobile headlights, in signals of all kinds, and in lighted instruments for the aid of the dentist and the surgeon.

Where else can we find a parallel to this lighting industry, which keeps doubling and doubling, and which still affords so much promise that a few years hence you will look back upon 1949 and say "That was only the beginning!" And let me add one thing more: Some of the greatest developments of the Twentieth Century have been used to destroy human life quite as much as to preserve it. Light, however, may be used as a defense but never as a weapon. It always has been helpful to mankind; it is never found on the wrong side of the ledger.

Now, it would be idle to claim that our Illuminating Engineering Society is solely responsible for all this lighting progress. Nevertheless, it has had a very substantial part in it. In one particular it has been the greatest factor: It has been the watchman for the public, seeing to it that lighting is kept "good"—good from the standpoint of the user and of his eyesight. It is significant, too, that experience has demonstrated many times that where lighting isn't very good, relatively little of it is used. We may take pride, too, in the fact that some of our own dues have been spent to finance university research in the lighting field, to increase knowledge for the benefit of all.

Often in addresses of welcome we have listened to the scriptural quotation "Let there be light." So often have we heard it that familiarity may have robbed it of much of its significance. However, I believe that the many public officials and executives who have used these words have been entirely sincere in according the production and distribution of light a first place amongst industrial vocations. Sometimes I think we fail to realize what real satisfaction each of us is entitled to for the dynamic lighting industry which our engineering skill and enterprise have helped to build, and particularly for what our organized illuminating engineering profession contributes in public benefits.

Straight Thinking Vital

Of course, there are certain types of twisted thinking today by self-recognized intellectuals and "planners" which would detract much from this satisfaction. They assail modern industry generally and impartially, claiming that those who operate it are motivated solely by a "low" desire for profits. Furthermore, they say that our economy has matured and that our system has become so well perfected that from now on progress will be automatic, and that the benevolent state should take over and act as an all-powerful and wise big brother. In fact, it is being said that private industry, including ours, has defeated its own function; that there is nothing left for it to do; and that the businessman or industrialist no longer retains the instinct of self-preservation. Now, these ideas are making some headway, for, whether we like it or not, this world is ruled principally by emotion, and one of the weaknesses of our capitalistic economy is that on the surface at least it is quite lacking in appeal to the emotions of the masses.

Let's look at that a little further. It took a Chinese scholar who knew both the West and the East to remind us that when one observes the body-breaking toil of the masses of the East, he should be religiously moved to bless the great inventors of the West who have devised machines and aids to do work for man and relieve him from the degrading hardships to which his Oriental neighbors are still subject. This same scholar declares that herein lies the real spirituality of material civilization; that when men and women must toil as they do in the Orient, unaided by machinery, there is little life and energy left for the general enjoyment of higher values. He also pointed out that when man first made fire accidentally by drilling wood, the invention was regarded as such a spiritual thing as to be attributed to one of the greatest of the gods. It is interesting, too, to discover that in the East all the legendary kings of China were not priests or philosophers, but inventors, such as the discoverer of fire, the first builder of houses, and the first teachers of agriculture and of medicine. After all, there never was an invention that was not first an idea; and an idea is not a material thing at all, but a thing of the spirit.

Let's Tell the Story

We also can let in a little light on the folly of believing in the doctrine of the matured economy. We all know that developments and processes are far from static. In our profession and industry this principle has been particularly evident. The difficulty today is that we have so many young people who have never experienced the oil lamp, the gas jet, the ice box, the horse and buggy, and other primitive objects. These young people are

particularly susceptible to the notion which is going around: That we now can rest easy; that industry is more or less automatic, calling not for aggressive imagination, but simply for conservation by so-called "planners." The average young person today takes for granted too many things which those of us who are older can compare with the predecessors of these implements. In other words, there are many people even of voting age who have no standards of comparison with the past in many respects. They have no conception of the long experimentation which calls for the expenditure of so much brainpower and so much capital. They were born into a world with efficient telephones, luminaires, refrigerators, washing machines, and many other implements which are sometimes contemptuously referred to as gadgets. These they take for granted and entertain at the same time the notion that all frontiers are gone; that we must cease concerning ourselves with ideas of progress, and go into a sort of state receivership.

Again, we who understand better than others the creative role of industry need to let in some light into the minds of our young people on the real character of free American business. On several occasions the economist of one of the large U. S. corporations has stated that a great deal of warped thinking of today is due to the fact that so many children have no notion whatsoever of how their fathers earn their living. The man I have in mind happens to be the grandson of pioneers who worked on the land, whose children saw from day to day how their father worked and participated in it with him. Today the picture has changed. Hundreds of thousands of men work in offices and laboratories far from their homes and their families who know little or nothing of how their living is earned, and few parents enlighten their families on these matters. Hence young men and women come home from college as did the daughter of a certain business man, confident that her father's company was a ruthless employer, "grinding the faces of the poor" and "concerned only with profits" and quite indifferent to the ordinary considerations of justice and fair play. Her father had never taken the time while she was in high school to explain to her even the rudiments of the business in which he was an executive. She was in constant conflict with him during the last two years of her college course, and particularly after graduating when she worked for a social agency and observed the squalor and misery which in her inexperience she attributed to "maladjustment brought about by the profit motive." Fortunately, in time and after her father had patiently thrown some light on some of the darkness in her mind, she began to see that many of the shallow arguments to which she had been exposed in college were not well founded.

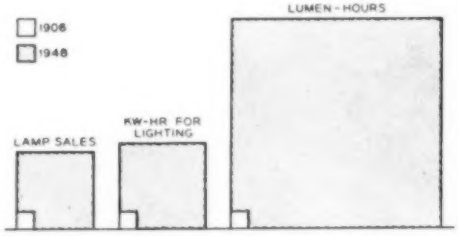
Rightly approached, we may find that new knowledge, invention, and technical processes *are* capable of making an emotional appeal and of stirring people's wonder and admiration for the accomplishments of science. The "intellectuals" wax enthusiastic over Galileo and Newton and Copernicus, early in the field of science. Perhaps if they were better informed they could experience a like admiration for some moderns like Faraday, Kelvin, Edison, Alexander Graham Bell, and others who toil in modern scientific laboratories.

It's What You Make It

And now let's apply some of this thinking more directly to our own Illuminating Engineering Society. By the end of its first year it had some 800 members and was growing steadily. Listed below are the names of its first 15 presidents, men in whom we may well take pride.

L. B. Marks	1906	Preston S. Millar	1913
Clayton H. Sharp	1907	Charles O. Bond	1914
Louis Bell	1908	A. S. McAllister	1914–15
Wm. H. Gartley	1909	Charles P. Steinmetz	1915–17
E. P. Hyde	1910	Wm. J. Serrill	1916–17
A. E. Kennelly	1911	G. H. Stickney	1917–18
V. R. Lansingh	1912	George A. Hoadley	1918–19
		S. E. Doane	1919–20

In each instance most certainly the office was seeking the man. It is significant, too, that all but two of them were members of the Society from the first year of its existence. All who met them knew that they were truly pioneers in a new field and that their ideals of service to the public were high. Only a minority of them are still with us



Comparison of usage in 1906, when the Society was organized, to 1948 is indicated by relative size of plain squares to shaded areas: electric lamp sales—20 times 1906 (to approx. 1 billion); electrical energy for lighting —25 times 1906 (to approx. 75 billion kwh); use of light in terms of lumen-hours—150 times 1906.

today. A most eminent one, dear to us all—Preston S. Millar—has just left us this summer; left, as I believe he wished to do, right at the close of a day's work. No one was more devoted to the ideals of the Society than Mr. Millar; no one saw more clearly that to be of value both to the public and to the industry, the Society must in every instance preserve its professional status and hold itself free from commercial activity. His interest in and his affection for the Society were a highly important part of his life.

And this brings me to the principal intent of the talk. When the Society was small and conventions brought together from 100 to 200 or 250 members, its ideals were well understood and subscribed to, but now that we have grown great there is the danger that we also may become impersonal. Do we have a dominating professional spirit, the sincere interest in this Society and its work, and the affection for it that we should, or do we merely take it as a matter of course — just a part of our business, in fact, rather than as a medium through which we can develop our understanding of a science and art, and pool our unselfish effort to further the well being, the health, and the happiness of many people? Much of the usefulness and success of the Society in the future will depend on how that question is answered.

Graduates of a college are presumed to have a warm place in their hearts for their Alma Mater, and, as Daniel Webster long ago reminded us, there are many who do; college songs contribute no small part today. We do not have the pull of I.E.S. songs to express our aspirations and to bring us together, and perhaps that's a lack that some member will correct; I hope so.

But whereas one's close connection with a college is usually limited to four years, with many of us our connection with the Illuminating Engineering Society is for the duration of our active lives, and continues on whether we are working in one enterprise or in another.

Those of you who have been with the Society longest know well that you attend its meetings and answer its calls for work not simply because your livelihood is in this field, but rather because for you the Society has come to have a high purpose and a personality, because it is a friend whom you are "delighted to honor" with your service.

Ward Harrison—1949 I.E.S. Gold Medallist

Engineer, teacher, author, designer, inventor, consultant, lecturer and leader, Doctor Ward Harrison has contributed to the art and technology of lighting to a degree unsurpassed by any member of the profession.

Fellow and eighteenth president of the Illuminating Engineering Society, he was the first to receive the honorary degree of Doctor of Illuminating Engineering awarded him in 1940 by the Case School of Applied Science.

For nearly two decades as director of engineering of the Lamp Department of the General Electric Company, he was in charge of the largest illuminating engineering organization in the world.

In addition to his term as President, he has served the Society constantly during almost his entire professional career having been chairman of ten important committees, a member of seven others, official representative to United States National Committee, I.C.I., and representative on Sectional Committee A.E.S.C. Because of his outstanding position in the profession he was invited to deliver the principal address at the 1948 Convention of the British Illuminating Engineering Society.

Designer of the RLM standard industrial reflector and of improved luminaires for street lighting, inventor of the Glassteel Diffuser and the clear-top, enclosed semi-indirect luminaire, his counsel with respect to new and improved products has enriched the lighting practice of the entire world.

Quantity determinations were greatly facilitated and made more precise by the establishment through his initiative of the now almost universally used coefficients of utilization and the room-index method of illumination calculations, while predetermination of degree of comfort through his system of numerical glare ratings has rendered quality less of a detached abstraction.

Through his writings and his thoughtful papers before technical groups, he has stimulated new approaches and initiated new criteria for better and more practical approaches to lighting problems.

For these and many other contributions to the art and science of illuminating engineering, the 1949 I.E.S. Gold Medal is awarded to Doctor Ward Harrison.

Brightnesses in Visual Field at Borderline Between Comfort and Discomfort (BCD)

By MATTHEW LUCKIESH and S. K. GUTH

QUALITY of lighting has been defined as a function of the brightness characteristics of certain unique portions of the visual field.[1] The brightnesses of these areas and the brightness-ratios between them contribute favorably or unfavorably to the *seeing conditions*. They may influence the visibility of a visual task, or their effects may be more subtle, insidious or deep-seated and result in decreased ease of seeing. Obviously, all the effects may be produced simultaneously. In general, it is an easy matter to provide the footcandle-levels within the restricted area of the visual task for the attainment of definite or generally adequate visibility-levels. However, the proper adjustment of all of the brightnesses in the entire visual field is of great importance to the worker who must perform tasks of critical seeing for prolonged periods in the resulting visual environment. Thus the ultimate goal of lighting practice is to provide brightnesses in the entire visual environment which produce the most satisfactory seeing conditions. This can be accomplished only by proper attention to, and application of, what has been termed *brightness engineering*.[2]

It may be considered axiomatic that the brightness relationships within the central field determine *directly* the visibility of any specific visual object or task. The brightness relationships in the surrounding field and between the central and surrounding fields determine *directly* the comfort of the visual environment and usually have an *indirect* or less obvious effect upon visibility. In other words, the *quality of lighting* may be such as to have little or no significant effect upon visibility but may result in extremely uncomfortable or distracting seeing conditions.

Many aspects of quality of lighting or the distribution of brightness in a visual environment have been investigated. The majority of these investigations* have dealt with the effects of brightnesses in the central and surrounding fields upon visual acuity,[3] contrast sensitivity,[4] rate of working,[5] and precision.[6] More recently a few investigations have been extended into a less obvious realm and have evaluated ease of seeing in terms of a number of psycho-physiological responses.[7] The available data permit the establishment of rather definite relationships concerning the more or less physical or visibility aspect of the problem. However, the relatively meager data of the evaluation of comfort and ease of seeing result only in qualitative conclusions. Therefore, the gap in our knowledge of the overall problem of providing ideal seeing conditions needs to be filled by additional comprehensive and quantitative investigations which can be correlated with lighting practice.

Since comfort and discomfort are sensations, their appraisal can be made only by those who experience such sensations. Different individuals may vary considerably in their appraisals, but the trends are decisive. Many years ago, Luckiesh and Holladay,[8] in their comprehensive investigation of the effects of bright light-sources upon visibility, included an attempt at appraising the psycho-physiological effects of glare. They developed a scale of comfort-discomfort or "degrees of sensation" from a scarcely noticeable sensation to intolerable and painful sensations. Holladay continued and extended this investigation. This early work involved glare-sources on the line of vision which, while useful in lighting practice, always assumed direct fixation of the glare-source. More recently we presented the results of a limited exploratory investigation of the effects upon comfort of glare-sources at various angular distances from the line of vision.[9] These data were somewhat useful for extending the general concepts and results of the previous work. However, all these investigations were limited in scope, and the results were difficult to apply directly to the evaluation of specific lighting installations. Therefore, a more extensive study of brightnesses in the visual field was planned which would include the wide range of the various factors involved with sufficient corollary investigations to make possible the practicalization of the basic and fundamental data.

Any comprehensive study of quality of lighting[1]

A paper presented at the National Technical Conference of the Illuminating Engineering Society held September 20-23, 1949, French Lick, Indiana. Authors: General Electric Co., Nela Park, Cleveland, Ohio.

*These references are not intended to be a complete bibliography of the literature but rather an indicator of the trends of researches during several periods.

or the environmental brightness relationships must include:

1. The brightness level to which the eyes are adapted.
2. The brightnesses of various areas in the visual field.
3. The area and position of sources of brightness.
4. The criticalness of the visual tasks to be performed.

The present paper presents the results of an extensive series of researches of the effects of sources of brightness in the visual field upon comfort and discomfort. Because of the scope of these researches it is necessary to limit this paper to a presentation chiefly of the basic relationships. Numerous additional results and analyses which make possible the correlation of the basic data with lighting practice will be the subject of a future paper.

Experimental Criterion, Environment and Procedures

Criterion. As has been stated previously, only those who experience and pay the penalties of glare can appraise discomfort and determine a scale of comfort and discomfort. When only two or three subjects are involved, it is possible to agree upon a series of definitions of various degrees of comfort and discomfort. However, any particular sensation would be a matter of considerable debate among a large group of individuals. Therefore, it was decided to confine the criterion of the present series of researches to a single sensation which could be defined by the experimenter and which could be interpreted by the subjects as a relatively definite sensation. Furthermore, it was desirable to establish a criterion which is meaningful from a practical viewpoint. It was decided that the *sensation at the borderline between comfort and discomfort* would fulfill these primary requisites. We have termed this the BCD sensation.

Experimental Environment. An important consideration of any investigation which involves a subjective evaluation of luminous areas in the visual field is the attainment of as complete control as possible of the environmental conditions. Without such control, extraneous factors may exert undue influence upon the subject whose appraisal may be of these factors rather than of the variable being studied. The experimental situation used in the present investigation involved (1) an extended visual field of uniform brightness termed the *field brightness F* and (2) a series of limited luminous areas of various brightnesses termed *sources*. For most of the present researches these conditions were obtained in an 80-inch photometric sphere, one-third of which was cut away as is illustrated in Fig. 1. The subject's head was positioned in a headrest so as to locate his eyes at the center of the sphere, or at a distance of 40 inches from the inner surface which occupied the *entire* unrestricted visual field. The brightness of this inner surface was the field brightness.

Figure 1. The experimental environment used throughout most of the present investigation was the illuminated white inner surface of an 80-inch sphere at the center of which the subject's eyes were located. This unrestricted surrounding visual field was illuminated by the lamp *L* located near the center of the sphere and concealed from the subject. The brightness of the test-sources *T*, which consist of circular apertures in the spherical surface, is adjusted by the control under the subject's right hand. The photograph illustrates the brief period during which a test-source *T* located 20 degrees above the line of vision was exposed.

The illumination of the entire visual field was obtained by placing a lamp immediately above the head of the subject. Since this position was approximately at the center of the sphere, the brightness *F* of the entire field was uniform throughout. A small shield was interposed between the lamp and head in order to eliminate any sensation of heat or brightness from above.

Light-sources mounted behind circular openings in the surface of the sphere provided the sources of brightness or luminous areas which the subjects were required to evaluate at the borderline between comfort and discomfort. By using appropriate filters in front of the light-sources, it was possible to obtain apparent constancy of color of the sources for a relatively large change in voltage. Therefore, by the selection of a lamp of proper wattage and a corresponding color-correcting filter, a reasonably constant spectral quality was maintained over the range of brightnesses from zero to approximately 30,000 footlamberts. This minimized the possibility of the color of the source influencing the judgment

of the subjects, since the spectral character of a 100-footlambert source was approximately the same as that of a 10,000-footlambert source. Each lamp and filter combination covered a limited range of brightnesses, an appropriate one being selected for each subject depending upon the variable being studied. In every case, the subject had available a sufficient brightness-range so that his evaluation would not be affected by the available limiting brightnesses.

Those sources which were not used during any particular part of the investigation were adjusted to equal the field brightness F and became indistinguishable from it. When two sources were being compared by alternate exposures, the brightness of either source during its "off" period was identical to the brightness of the field. Thus, the experimental environment always consisted of a uniform field brightness F with a circular luminous area periodically superimposed upon it.

Technique. The technique used for appraising the brightnesses of the sources was similar to that originally developed by Luckiesh and Holladay[8] but with refinements of procedure which were dictated by later experience and knowledge. The subject was required to evaluate the initial sensation of brightness when a source was momentarily exposed to view amid the surrounding field of uniform brightness F. In other words, the condition approximated that of a worker looking up from the adaptation brightness of a large area, such as his desk, to a source of higher brightness and evaluating the sensation received during the brief period that the source was viewed. Short exposures were used instead of prolonged exposures owing to the desire to maintain the adaptation brightness-level as close to that of the surrounding field as possible. However, the exposure-time was sufficiently long for the observer to receive and to experience the full building up of the sensation. The authors believe it is desirable and even essential to control the duration of exposure to the source. After considerable experimentation we have standardized upon 1-second exposures separated by 1-second intervals during which the subjects were exposed only to the field brightness. A 10-second cycle was devised during which the sources were presented for a subjective evaluation three times and the remaining short period was allowed for the subject to alter the brightness of the test-source.

An absolute method and also a comparison method were used. It was found that both types were reliable and consistent. The absolute method was most suitable when a single test-source was used or when the variables being investigated included more than one field brightness. The comparison method was quite suitable for those phases of the investigation in which the test-source being evaluated was displaced from the line of vision, which permitted locating a standard or comparison-source on the line of vision, or when the angular displacement between sources was sufficiently small to permit alternate direct fixation with minimal movement of the eyes.

The exposure-cycle of the absolute method involved three 1-second "on" periods of the test-source separated by 1-second "off" periods and followed by a 5-second "off" period. The 5-second period was provided so that the subject could resolve the sensations received during the "on" periods and alter the brightness of the test-source for the next appraisal if he wished. The criterion used throughout the present investigation was the sensation at the borderline between comfort and discomfort, or the BCD sensation. The subject was free to establish his own criterion of BCD brightness and was permitted as many 10-second cycles as he deemed necessary to make a complete appraisal for each condition.

When the comparison method was used, the comparison-source C was set at a predetermined brightness by the experimenter. The brightness of the test-source T was then adjusted by the subject so that the initial sensation received from it was the same as the initial sensation received from the comparison-source. The sources were exposed alternately for 1-second periods with 1-second intervals between exposures and a 5-second "off" period for evaluating the sensation of brightness and for altering the brightness of the test-source. During two successive cycles the order of presentation of the two sources was reversed. For example, the order during even-numbered cycles was C—T—C, each exposure being for one second with 1-second "off" intervals between exposures. This was followed by a 5-second interval during which the subject saw only the uniform field brightness. During the odd-numbered cycles the order was T—C—T so as to minimize any influence of the order of presentation. As with the absolute method, the subject was permitted as many cycles as necessary for making an appraisal. The field brightness F was maintained constant and continuous for each specific condition and series of observations.

In considering controlled conditions, it is also necessary to minimize the influence of the experimenter upon the subjects. After adequate explanation of the procedure, the subject was left alone to arrive at his conclusion at each step in the investigation. The handling of subjects is very important.

Basic Relationships

In this section of this paper the basic factors which affect the visual sensation produced by a

source or luminous area are restricted to the size and brightness of the source and to the uniform brightness of the entire adapting field. The position of the source in the visual field, the configuration of the source and the number of sources that are visible are modifying factors which are considered separately in later sections.

Standard BCD Brightness. It was first necessary to establish a meaningful brightness value for standardized conditions and one that could be used as a common denominator for relating all the variables. This was accomplished by selecting as the criterion a brightness sensation which was at the borderline between comfort and discomfort. We have termed this the BCD brightness for the specified condition. This datum should be the average from a large number of subjects in order for it to be a representative value. It then becomes the standard BCD brightness for the standard test-conditions as viewed by a standard subject. The standard test-conditions included (1) a circular source having a diameter of 1.48 inches, (2) located on the line of vision, (3) at a distance of 40 inches from the eyes and (4) a surrounding field brightness of 10 footlamberts. At this viewing distance, the circular source subtended a solid angle of 0.0011 steradian. The absolute method was used for determining the basic relationships. The source brightness was always viewed directly by the subjects who adjusted it until it was judged to be at the BCD brightness for the specific conditions.

It will be noted that the background brightness, against which the source is viewed, has not been included among the basic or modifying factors. In order that the results of these researches be useful, the background brightnesses are considered to be less than the brightness of the source and of the same order as the adaptation brightness as is often encountered in practice. In this investigation the background and adaptation brightnesses were identical. Obviously, if the background is of the same brightness as the source, it becomes a part of the source and thus contributes to the visual sensation received from the source.

A random group of 50 subjects varying in age from 20 to 40 years was used for determining the standard BCD brightness of the standard source viewed under the standard test-conditions. The average BCD brightness for each of the subjects is presented in Table I. It is seen that the individual BCD brightnesses range from 315 to 1600 footlamberts and that the geometric mean BCD brightness of the standard source is 830 footlamberts. An analysis of the data indicates that an approximately normal distribution was obtained from the 50 subjects. The variation between individuals is not unexpected nor extraordinary because of the many physiological and psychological factors which may influence the subjective appraisal of bright areas. Contrast sensitivity, for example, has been used as a criterion of retinal sensitivity and has been demonstrated to vary widely for a group of subjects who may be otherwise rated equal, and are socalled normal, on a visual-acuity basis.[10] Furthermore, standards of comfort or discomfort vary greatly among individuals. However, the normalcy of the distribution is an indication that the mean value is representative of a much larger group. The geometric mean and the arithmetic mean are of the same order of magnitude, differing by approximately 7 per cent. The geometric mean is particularly useful for these types of data since it is less affected by extreme values than the arithmetic mean, and hence it is a more typical average especially when there is a relatively wide spread of the data. In actual practice "factors of safety" should be provided so that no sources in the visual field are in the discomfort realm beyond the borderline BCD for any one of a representative group of persons. Thus the average BCD brightness is suitable for establishing general relationships, but it may be desirable to use the lowest BCD brightness as a conservative value for determining the brightness relationships in a visual environment when comfort is of primary importance.

It is of interest to compare the average BCD brightness obtained in the present investigation

TABLE I.—The BCD brightness in footlamberts of the standard circular source (subtending 0.0011 steradian) located on the line of vision which produced an initial momentary sensation as judged by each of 50 different subjects to be at the borderline between comfort and discomfort. The field brightness was 10 footlamberts.

Subject	Brightness	Subject	Brightness
1	410	26	1040
2	820	27	910
3	1040	28	1530
4	880	29	1300
5	910	30	670
6	1170	31	990
7	580	32	850
8	910	33	1380
9	1300	34	625
10	885	35	405
11	1600	36	630
12	450	37	950
13	1060	38	810
14	1530	39	1440
15	930	40	810
16	370	41	985
17	445	42	640
18	400	43	650
19	750	44	470
20	990	45	1230
21	860	46	820
22	1170	47	980
23	955	48	1080
24	1000	49	840
25	315	50	770
		Arithmetic Mean	891
		Geometric Mean	830

with the value obtained by applying the so-called Holladay formula,[8]

$$K = \log B + 0.25 \log Q - 0.3 \log F \qquad (1)$$

where K expresses the magnitude of the initial sensation of a "glare-source" having a brightness of B millilamberts and subtending a solid angle of Q steradians when the adapting field brightness is F millilamberts. The value of K was originally determined by Luckiesh and Holladay to be 1.9 when the sensation was at the boundary between comfort and discomfort. Substituting $Q = 0.0011$ steradian, $F = 10$ footlamberts and $K = 1.9$ in the formula, the calculated BCD brightness is 827 footlamberts as compared with the mean value of 830 footlamberts found in the present study. In other words, the two groups of subjects, under similar test conditions, appraised the same brightness as being at the borderline between comfort and discomfort. However, in the present investigation the group of subjects was much larger and, therefore, may be considered to be more representative of the average.

Influence of Field Brightness. The effect of the field or adaption brightness upon the BCD brightness is illustrated in Fig. 2. These data were determined by a group of ten subjects so selected as to be representative of the 50 subjects used previously for the determination of the standard average BCD brightness. All factors, excepting the field brightness, were maintained at the standard values. That is, the size of the source was 0.0011 steradian and was located on the line of vision. For field brightnesses of 1, 10 and 100 footlamberts the average BCD brightnesses were found to be 302, 830 and 2325 footlamberts, respectively. These values, which plot as a straight line on logarithmic coordinates, may be represented by the equation

$$B = 302F^{0.44} \qquad (2)$$

where B is the BCD brightness of the source and F is the field brightness. From this relationship it is seen that doubling the field brightness F permits a 36 per cent increase in the brightness B of the source. Conversely, if the brightness B of the source is doubled, the field brightness F must be increased approximately five times in order to maintain the BCD sensation.

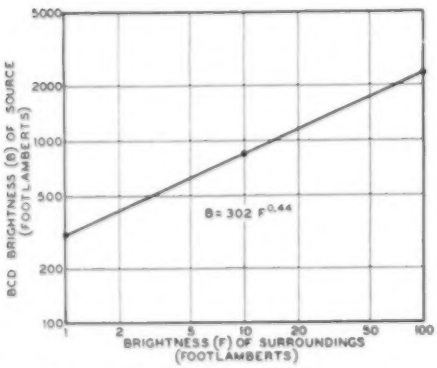


Figure 2. The relationship between BCD brightness B of a source, located on the line of vision and subtending a solid angle of 0.0011 steradian, and the surrounding field brightness F.

The straight-line relationship agrees with that found by Luckiesh and Holladay[8] and by Nutting.[11] The coefficient of F as determined by these earlier investigators was higher primarily because the criterion used by them involved the sensation of glare rather than the BCD brightness which is at the borderline between comfort and discomfort and is defined as being less than the sensation of glare in its usual meaning. The difference between the values of the exponent may be due to slightly different experimental situations and techniques and to the differences between the subjects used in the various investigations. We believe that the group of subjects used in the present investigation is more representative of the average than in the earlier work. Holladay, for example, found that the exponent was somewhere between 0.15 and 0.4 with a probable average value of 0.3. The value found in the present work is 0.44 which is approximately the same as Holladay's upper limit.

Influence of Size of Source. A series of five circular sources was used for determining the effect of size upon the BCD brightness. The relative sizes of these sources, which subtended solid angles from 0.0001 to 0.126 steradian, are illustrated in Fig. 3. The actual sizes, which were viewed at a distance of 40 inches, varied from 0.46 inch to 16 inches in diameter. In table II are summarized the physical data pertaining to the circular sources and the average BCD brightnesses as determined by the representative group of subjects for a field brightness of 10 footlamberts. These BCD brightnesses are indicated in footlamberts on Fig. 3 for each of the circular sources and are plotted as the solid line of Fig. 4 for a field brightness of 10 footlamberts.

The relationship between the size of the source Q in steradians and the BCD brightness B in footlamberts approximates a linear logarithmic one for a range of Q from 0.0001 to 0.01 steradian. However, the BCD brightness decreases more rapidly for larger sources, from 0.01 to 0.13 steradian, than for smaller sources. The straight-line portion of the curve includes the range of sizes used by Holladay who also found a straight-line relationship. The

Figure 3. The relative sizes of the five circular sources used for determining the effect of size upon BCD brightness for a field brightness of 10 footlamberts. The point of fixation "X" was at the center of each of the sources.

empirical equation for the straight-line portion of the curve is

$$B = 102Q^{-0.30} \tag{3}$$

For the entire range of Q used in the present researches, the empirical equation is

$$B = 296Q^{-0.21} - 377 \tag{4}$$

The exponents of Q are in general agreement with Holladay who found that a value of 0.25 gave a good approximation for the range he studied.

The inverse relationship between BCD brightness and size of source is obvious. However, it is a variable relationship and the change in one factor required as a result of an increase or decrease in the other factor is dependent upon the absolute values of size and brightness that are involved. For example, when the size Q of the source is less than 0.01 steradian, doubling its brightness requires that it be reduced to one-tenth of its original size. As the size of the source is increased progressively above 0.01 steradian, a doubling of its brightness requires progressively less of a reduction in size. The reasonableness of these results is obvious when it is considered that large sources cover a substantial part of the visual field and become a greater factor in the brightness to which the eyes are adapted. Furthermore, the BCD brightnesses of large sources are relatively low in comparison with the BCD brightnesses of small sources and therefore, the effects of changes in size are relatively diminished.

It is emphasized that the relationship given in equation (4) holds *only* for the range of the experimental data and cannot be extrapolated for larger sizes of sources without obtaining BCD values which are without meaning. For example, if equation (4) were extended in range to a source subtending a solid angle of about 0.32 steradian, the BCD brightness would become zero, and for larger sources would be a negative quantity. Obviously this is an empirical equation of limited range. Nevertheless, the results do indicate that large expanses of luminous areas become uncomfortable when their brightnesses are relatively low. For many years we have emphasized[12] this fault of indirect lighting in large interiors and have advocated general illumination *plus* supplementary lighting.[1,2] However, a large source may include a considerable portion of the visual field and part of it may be in view at all times. Thus the large source may contribute directly to the adaptation brightness which will be higher. Therefore, the sensation of brightness when the source is viewed directly may be appreciably mitigated.

It is interesting to compare the diameters and areas of sources of the same solid angle when they are viewed at 40 inches, the distance used in this investigation, and, for example, when they are viewed at 10 feet. The sizes of the sources for the two distances are presented in Table II. At the viewing-distance of 10 feet a circular source subtending a solid angle of 0.0079 steradian has a diameter of 12 inches, and an area of 113 square inches and approximates an enclosing globe. The largest source used in the investigation was 16 inches in diameter at a viewing-distance of 40 inches. A source of the same visual size would have a diameter of 48 inches when viewed at 10 feet. The area at this distance is 1810 square inches or approximately 12.5 square feet. When a source of this size is fixated centrally, the visual angle subtended by its diameter is 22.6 degrees. In other

TABLE II.—Dimensions of the circular sources and the average BCD brightnesses in footlamberts of these sources, located on the line of vision which produced an initial momentary sensation judged to be at the borderline between comfort and discomfort. The field brightness was 10 footlamberts.

Size of source, steradians	0.0001	0.0011	0.0079	0.0314	0.126
Visual angle, degrees	0.66	2.12	5.72	11.42	22.62
When viewing distance is 40 inches or 3 1/3 feet					
Diameter, inches	0.46	1.48	4.0	8.0	16.0
Area, square inches	0.167	1.72	12.6	50.3	201
When viewing distance is 120 inches or 10 feet					
Diameter, inches	1.38	4.44	12.0	24.0	48.0
Area, square inches	1.5	15.5	113	453	1810
BCD Brightness, footlamberts	1660	830	447	237	82

words, the central visual field is covered by this source. Furthermore, a source of this size begins to approach a large segment of an indirectly illuminated or luminous ceiling. Thus these data can be used to indicate the BCD brightness of either small or relatively large areas in a visual environment.

Basic Relationships. When the relationships between the BCD brightness B of a source in the visual field, the size of source Q, and the field brightness F for the entire range of the experimental data are combined the following empirical formula is obtained from equations (2) and (4):

$$B = 108F^{0.44}(Q^{-0.21} - 1.28) \qquad (5)$$

This is plotted in Fig. 4 for three values of F. The points for which experimental data were obtained are indicated by the solid dots. Dotted lines have been drawn parallel to the 10-footlambert curve for field brightnesses of 1 and 100 footlamberts. This parallel relationship has been adequately established by Holladay and was spot checked in the present investigation.

From Fig. 4 it is seen that, for a constant BCD brightness, if the field brightness is increased, the size of the source may also be increased, but not in a constant ratio. For a given BCD brightness of a source, the permissible increase in the size of the source depends upon its absolute size. For example, for a given BCD brightness of a source when the size of the source is only 0.001 steradian, the area of the source may be increased about 2.6 times, or to 0.0026 steradian, if the field brightness is doubled. However, when the size of the source is as large as 0.1 steradian, its area may be increased by a factor of only 1.3, or to 0.13 steradian, when the field brightness is doubled. In other words, when the brightnesses of sources are increased, considerable care must be exercised to make the necessary compensating increase in the field brightness or decrease in the size of the source or both.

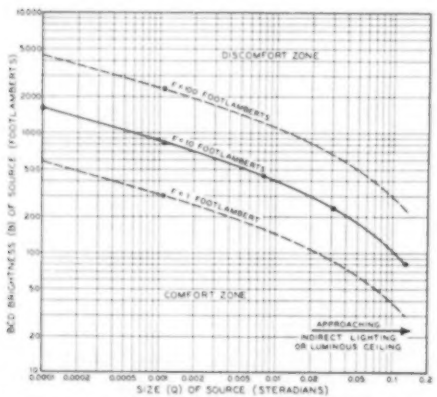

DISCOMFORT ZONE
F = 100 FOOTLAMBERTS
F = 10 FOOTLAMBERTS
F = 1 FOOTLAMBERT
COMFORT ZONE
APPROACHING INDIRECT LIGHTING OR LUMINOUS CEILING
BCD BRIGHTNESS (B) OF SOURCE (FOOTLAMBERTS)
SIZE (Q) OF SOURCE (STERADIANS)

Figure 4. The relationship between BCD brightness B and size Q of sources located on the line of vision for three surrounding field brightnesses F.

Figure 5. Locations of the circular test-sources along the vertical, diagonal and horizontal meridians. The diameter of the sources was 1.48 inches or 0.0011 steradian at a viewing distance of 40 inches.

Position of Source in Visual Field

In a previous paper,[9] the authors presented the results of a limited investigation of the relative brightnesses above and to one side of the line of vision which produced the same initial visual sensation. The present researches were designed to extend the scope of the previous work and to determine more explicitly the effect of displacing a source from the line of vision.

Circular sources of brightness were located at various angular distances from the line of vision along three meridians—vertically, diagonally and horizontally—as is illustrated in Fig. 5. The diameter of the sources was 1.48 inches which, at a viewing distance of 40 inches, subtended solid angles of 0.0011 steradian. These circular sources were located on the inner surface of the sphere at a constant distance from the eyes which were at the center of the sphere. Therefore, these sources were constant in visual size and shape. The brightness of the surrounding field, which extended over the entire visual field, was maintained at 10 footlamberts. The comparison method as previously described was used for determining the BCD brightness of the sources as they were displaced at various angular distances from the line of vision. The central source which was viewed directly by the

TABLE III.—BCD brightnesses in footlamberts of circular sources (subtending 0.0011 steradian) located at various angles (θ) from the horizontal line of vision. The field brightness, which extended over the entire visual field, was 10 footlamberts. (See Fig. 5).

Angle θ from line of vision in degrees	BCD Brightness in Footlamberts		
	Vertical	Diagonal	Horizontal
0	830	830	830
5	1165	1020	886
10	1344	1051	928
20	1764	1338	1037
30	2764	1967	1254
40	4452	2937	1463
50	7615	4500	2015
60	14000*	7658	2566
70	.....	13500*	3423
80	.....	.....	5212
90	.....	.....	8396
100	.....	.....	15000*

*Outside of visual field for some subjects.

subjects was set at the standard BCD brightness of 830 footlamberts determined in the basic phase of the investigation. The eyes of the subject remained fixed on the position of the central source and the off-axis sources were seen by averted vision. Since the comparison source was at the BCD brightness, and the off-axis sources were adjusted by the subjects for the same initial momentary sensation of brightness, the latter are also BCD brightness. The comparison-source and the off-axis source were exposed alternately for 1-second intervals.

In Table III are summarized the average BCD brightnesses as determined by the representative group of 10 subjects. The observed values are also diagrammatically presented in Fig. 6, where the cross at zero degrees represents the point of fixation while appraising the displaced sources by averted vision. The angular displacement of the sources was extended to cover the limits of the visual fields for all subjects. For example, all of the subjects were able to see a source located 50 degrees above the line of vision, but only four were able to see the source at 60 degrees. The latter datum was used for extrapolating the average curve to 60 degrees. Similarly, sources displaced 70 degrees diagonally and 100 degrees horizontally were outside the visual field for some of the subjects.

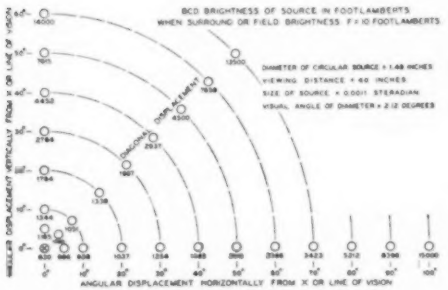

BCD BRIGHTNESS OF SOURCE IN FOOTLAMBERTS
WHEN SURROUND OR FIELD BRIGHTNESS F = 10 FOOTLAMBERTS
DIAMETER OF CIRCULAR SOURCE = 1.48 INCHES
VIEWING DISTANCE = 40 INCHES
SIZE OF SOURCE = 0.0011 STERADIAN
VISUAL ANGLE OF DIAMETER = 2.12 DEGREES
VERTICAL
DIAGONAL
HORIZONTAL
ANGULAR DISPLACEMENT VERTICALLY FROM X OR LINE OF VISION
ANGULAR DISPLACEMENT HORIZONTALLY FROM X OR LINE OF VISION

Figure 6. A diagrammatic representation of vertical, diagonal and horizontal displacement of test-sources from the point of fixation "X." The BCD brightness for each source location is indicated below the respective circles for a field brightness of 10 footlamberts.

Averages obtained by the individual subjects indicate that the relative brightnesses selected for the BCD values varied approximately the same as those obtained for the standard BCD brightness. That is, some subjects appear to be more sensitive to brightness than others, and hence their BCD brightness is lower than that obtained by the less sensitive subjects. However, it was found that a subject generally fell into the same position throughout all of the tests. In other words, a subject selecting high BCD brightnesses always selected high values. It is interesting to note that when the angular displacement of the source from the line of vision is small, the variation among subjects is small, being about a 2:1 ratio. However, as the angular displacement increases, the variation among subjects becomes greater and reaches a maximum of about 10:1. In other words, central vision appears to be more uniform among a group of subjects than does peripheral vision. Such a variation is to be expected because of individual variations in judgment, retinal sensitivity and other psychological and physiological factors. Seeing by averted vision involves focusing the attention on a given object while focusing the eyes on another object. This inherent difficulty apparently increases with the angular separation of the two objects. Nevertheless, the average BCD brightness is a useful value for specifying brightness relationships in the visual field provided a suitable "factor of safety" is used. In other words, the average BCD brightness for a large group of persons is always of a higher value than the lowest individual value. This point is discussed later.

In Fig. 7 is presented graphically the manner in which the BCD brightnesses increase as a source is displaced from the line of vision in different meridians. The heavy lines representing the vertical, diagonal and horizontal displacement are smooth curves drawn through the average observed values which are indicated by the circles. The thinner lines for the intermediate meridians have been interpolated. From these curves it is seen that a source of a given brightness is more effective in producing a given sensation when displaced horizontally from the line of vision than it is when displaced the same angular distance vertically above the line of vision. For example, when the field brightness is 10 footlamberts, a source having a brightness of 2000 footlamberts must be displaced 50 degrees horizontally

but only 23 degrees vertically in order to be at the borderline between comfort and discomfort. Or, stated in another way, a 2000-footlambert source displaced 50 degrees horizontally and a 7600-footlambert source displaced 50 degrees vertically are both BCD brightnesses for the standard experimental conditions.

No significant change in the curve of Fig. 7 for horizontal displacement is noticeable at the transition point between binocular and monocular perception of the sources. The actual transition point varied from subject to subject, being dependent upon facial configuration, and ranged from approximately 40 to 50 degrees. An examination of individual data revealed no sudden change in BCD brightness which could be attributed to this factor.

The relationships between the vertical BCD brightnesses and the diagonal and horizontal BCD

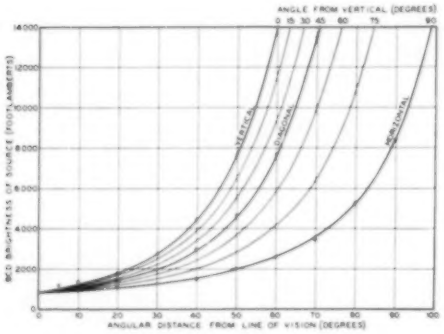


Figure 7. Illustrating how the BCD brightness increases as a circular source, subtending a solid angle of 0.0011 steradian, is displaced along various meridians from the line of vision. The heavy lines represent observed data for vertical, diagonal and horizontal displacement. The thinner lines for the intermediate meridians have been interpolated. These data were obtained when the field brightness was 10 footlamberts.

brightnesses are illustrated in Fig. 8. In this diagram the BCD brightness at each diagonal and horizontal angle is expressed relatively to the vertical BCD brightness at the same angle. For example, a source located on the diagonal meridian 50 degrees from the line of vision can be only 60 per cent of the corresponding BCD brightness of a source located 50 degrees from the line of vision on the vertical meridian. Similarly, a source displaced 50 degrees horizontally from the line of vision can be only 27 per cent of the corresponding vertical BCD brightness. The observed points are indicated by the circles and result in approximately linear rela-

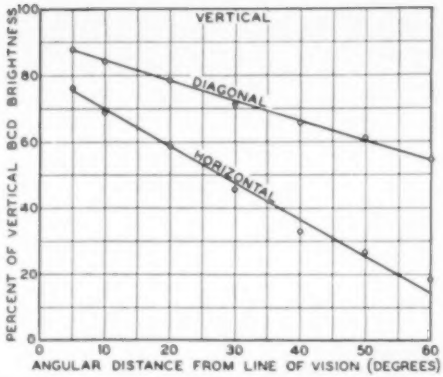


Figure 8. The relative BCD brightnesses of sources displaced along the diagonal and horizontal meridians in per cent of the BCD brightness of a source displaced the same angular distance along the vertical meridian. The size of the test-sources was 0.0011 steradian and the field brightness was 10 footlamberts.

tionships for the useful range to 60 degrees from the line of vision.

A graphical illustration of the variation of BCD brightnesses of the circular sources located in the visual field above the horizontal is presented in Fig. 9 when the point of fixation is at zero degrees. The heavy solid curved lines represent iso-BCD brightnesses and are lines of equal BCD brightnesses. A striking point is the similarity between the shape of the BCD curves and the curve representing the boundary of the visual field. The latter dotted curve is based upon data published by Duke-Elder, Sheard and others.[13] The extent of the visual field is greatly dependent upon physiognomy or facial topography and upon the retinal characteristics of any particular individual. The slight dip in the curves along the vertical meridian is real and also

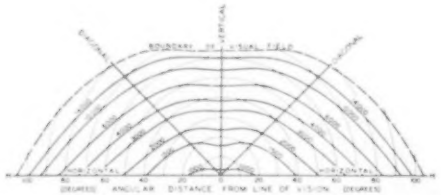


Figure 9. A graphical illustration of the variation of BCD brightnesses of circular sources (subtending 0.0011 steradian) located in the visual field above the horizontal. The point of fixation was at zero degrees and the brightness of the field was 10 footlamberts. The heavy solid curved lines represent points of equal BCD brightness. The broken curve represents the boundary of the visual field.

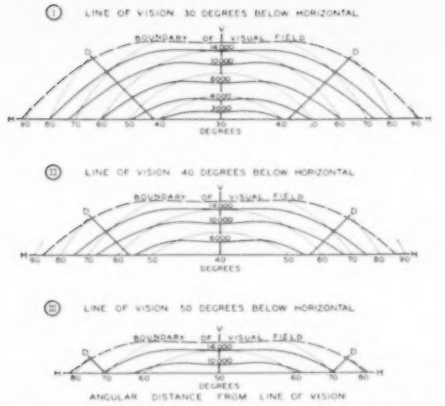

① LINE OF VISION 30 DEGREES BELOW HORIZONTAL
BOUNDARY OF VISUAL FIELD
DEGREES
② LINE OF VISION 40 DEGREES BELOW HORIZONTAL
BOUNDARY OF VISUAL FIELD
DEGREES
③ LINE OF VISION 50 DEGREES BELOW HORIZONTAL
BOUNDARY OF VISUAL FIELD
DEGREES
ANGULAR DISTANCE FROM LINE OF VISION

Figure 10. Illustrating the extent of the visual field above the horizontal and the permissible BCD brightnesses of sources (subtending 0.0011 steradian) when the line of vision is depressed below the horizontal. The field brightness was 10 footlamberts.

appears to follow the shape of the boundary of the visual field.

Fig. 9 is predicated upon the subject's line of vision being horizontal and the point of fixation at zero degrees. However, one often is more interested in that part of the visual field *above* the horizontal when the line of vision is depressed *below* the horizontal. Diagrammatic views of this are presented in Fig. 10. It is seen that, as the line of vision is depressed more and more below the horizontal, that part of the visual field in which bright areas ordinarily are located becomes progressively smaller. For example, as shown in I, Fig. 10, when the line of vision is 30 degrees below the horizontal, the visual field extends vertically above the horizontal only about 33 degrees and laterally on the horizontal about 60 degrees. In III, Fig. 10, when the line of vision is 50 degrees below the horizontal, which approximates looking down at a desk, the extent of the visual field is only 13 degrees vertically and 30 degrees horizontally. In other words, there is but a small area in which sources can be seen and for the latter example the minimum BCD brightness is about 8000 footlamberts when the size of the source is 0.0011 steradian and the field brightness is 10 footlamberts. Nevertheless, the line of vision at times may and often will be horizontal or above the horizontal. Therefore the complete diagram of Fig. 9 cannot be neglected or ignored.

In Table IV are presented the BCD brightnesses taken from the smooth curves of Fig. 7 for sources located at various positions in the visual field, having a size of 0.0011 steradian (1.48 inches in diameter, viewed at 40 inches) and a surrounding field brightness of 10 footlamberts. These BCD brightnesses may be increased by 36 per cent if the field brightness is 20 footlamberts and by 85 per cent if the field brightness is 40 footlamberts. However, if the size of the source is increased by a factor of ten, the brightnesses of Table IV must be halved.

The relationship between the BCD brightness and the position of a source in the visual field is necessarily a complex one since it involves physiological and psychological factors. Either Fig. 7 or Fig. 9 may be used for determining the relative BCD brightness of a source located anywhere in the visual field. However, they involve the measurement or calculation of the angle of a meridian from the vertical and the angular displacement of the source from the line of vision along this meridian. In other words, on these diagrams, the source is considered to be on the surface of a sphere.

In establishing a more practical relationship, it is desirable to consider that the source is located in a vertical plane normal to the horizontal line of vision. Thus, the position of a source may be defined by a vertical distance V above the horizontal line of vision and a lateral distance L from the point where the horizontal line of vision intersects the vertical plane. By expressing these distances in terms of the distance R from the eye to the vertical plane, the numerical values $\frac{V}{R}$ and $\frac{L}{R}$ become simple factors for determining a *position index P*. If the position index P is in terms of the relative BCD brightness, it becomes a relatively simple matter to determine the BCD brightness of a source located anywhere in the visual field above the line of vision. The position indexes P, or the relative BCD brightnesses of sources located at various positions in the visual field, are presented in Fig. 11. It is seen that Fig. 9 and Fig. 11 are similar except that linear measurements are involved in the latter.

TABLE IV.—BCD brightnesses of a circular source located at various positions in the visual field when the size of the source is 0.0011 steradian and the brightness F of the surrounding field is 10 footlamberts.

Angular Distance from Line of Vision (Degrees)	BCD Brightnesses for Various Radial Angles from the Vertical (Footlamberts)						
	Vertical		Diagonal			Horizontal	
	0	15	30	45	60	75	90
0	830	830	830	830	830	830	830
10	1230	1160	1120	1070	1020	980	930
20	1790	1670	1530	1400	1290	1170	1060
30	2770	2520	2260	1980	1730	1470	1250
40	4400	3910	3420	2940	2480	1990	1540
50	7640	6450	5550	4500	3730	2900	1960
60	14000	11800	9700	7660	5860	4150	2600
70	.....	.....	.....	13500	10000	6400	3580
80	.....	.....	.....	.....	.....	11140	5200
90	.....	.....	.....	.....	.....	.....	8400
100	.....	.....	.....	.....	.....	.....	15000

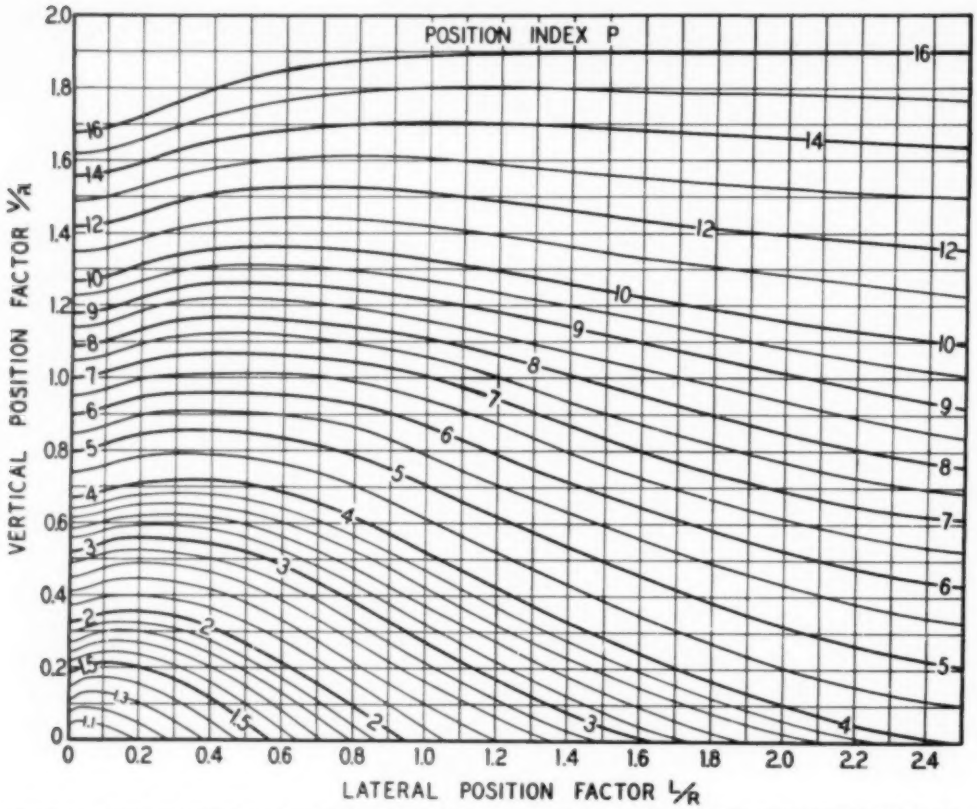


Figure 11. Chart for determining the Position Index *P* of sources located at various positions in the visual field. *V* and *L* are the vertical and lateral distances, respectively, from the line of vision and *R* is the distance from the eye to the vertical plane normal to the line of vision in which the source is located.

Equation 5, which is for a source located on the line of vision may be extended to include a source located anywhere in the visual field above the line of vision by incorporating the position index *P*. The position index *P* indicates the relative BCD brightness of a source displaced from the line of vision in terms of the BCD brightness of a source located on the line of vision. In other words, if the BCD brightness of a specific source located on the line of vision is *B* footlamberts, the permissible BCD brightness is *BP* footlamberts when the same source is displaced from the line of vision. Thus equation (5) becomes

$$B = 108PF^{0.44}(Q^{-0.21} - 1.28) \qquad (6)$$

This expression may be rewritten as

$$M = \frac{B}{PF^{0.44}(Q^{-0.21} - 1.28)} \qquad (7)$$

or

$$\log M = \log B - \log P - 0.44 \log F - \log (Q^{-0.21} - 1.28) \qquad (8)$$

Thus *M* becomes an index of the sensation of visual comfort when a source is exposed to view. When *M* is equal to 108, the combination of source-brightness *B*, size *Q* and position index *P* and the field brightness *F* are such that the initial sensation of brightness received from the source is at the borderline between comfort and discomfort or BCD. Smaller and larger values of *M* indicate greater comfort or discomfort, respectively. Log *M* corresponds to the *K*-factor developed by Luckiesh and Holladay[8] who found a value of *K* equal to 1.9 for the BCD brightness. In the present investigation log *M* (when $M = 108$) is 2.03 when the sensation is at the borderline between comfort and discom-

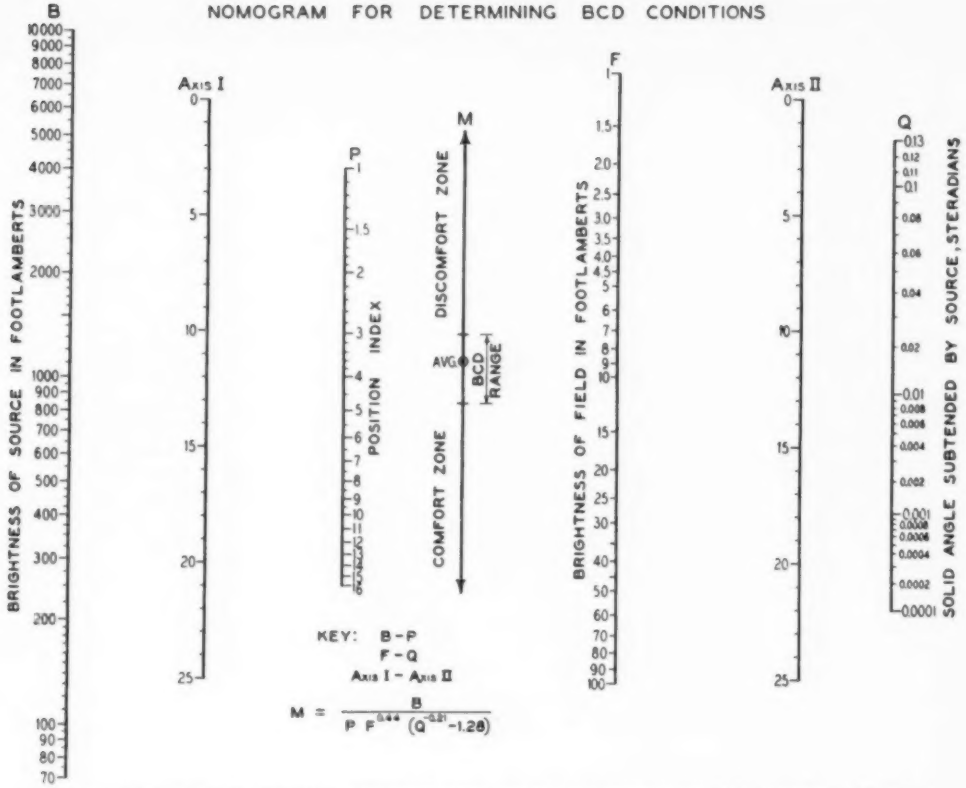


Figure 12. A nomogram for calculating the factors which combine to determine the BCD brightness of a source.

fort. The absolute values of K and log M are dependent upon exponents of F and Q, which in turn are a function of the characteristics of the specific subjects used in the respective investigations.

The nomogram of Fig. 12 and the disk calculator illustrated in Fig. 13 have been designed to facilitate the calculation of the various factors which combine to determine the BCD brightness of a source. It will be noted that the M-line has not been given scale values. It is re-emphasized that the present investigation had as its purpose the establishment of the relationships between the factors which produce a sensation at the borderline between comfort and discomfort. Therefore, any value of M other than the BCD value has no numerical significance except to indicate that a source is in the comfort zone or discomfort zone. Three relative BCD values of M have been indicated. The average value has been used throughout this discussion and is indicated by the circled dot on the M-line. The BCD range has been determined from the individual maximum and minimum BCD brightnesses selected by the 50 subjects who were involved in the basic phase of this series of researches. The average BCD value merely means that *half* of any given group can be expected to find the sensation of brightness from a source to be at, or more comfortable than, the borderline between comfort and discomfort. If comfort is of major importance in a visual environment, the lower BCD limit may be used and the resultant sensation would be expected to be less than BCD for most of the group. Conversely, if comfort is of little moment, the upper BCD limit might be used.

The scales along Axis I and Axis II of Fig. 12 are merely for convenience and have no significance. These axes are turning points for combining the various factors and the scales should be helpful in relating the right and left sections of the nomogram.

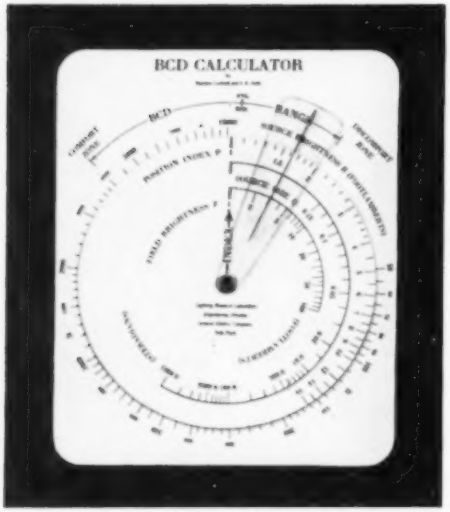


Figure 13. A disk calculator which contains in circular form the scales of the nomogram of Fig. 12.

Any one of the factors may be determined on the nomogram if the other factors are known or specific values are assumed. Several examples will serve to illustrate the method of using the nomogram.

Example 1. It is desired to ascertain whether a given source produces an effect of discomfort for the following conditions:

Brightness B of source	= 3000 footlamberts
Size Q of source	= 0.02 steradian
Brightness F of field	= 50 footlamberts
Position index P	= 5 (from Fig. 11)

Draw a line from $B = 3000$ to $P = 5$ and from $F = 50$ to $Q = 0.02$. From the intersections of these lines with Axis I and Axis II, respectively, draw a third line. The intersection of this third line with M indicates the relative degree of the sensation produced by the source, which in this case is BCD.

Example 2. It is desired to determine the BCD brightness of a source when $F = 40$ footlamberts, $Q = 0.01$ steradian and $P = 2$. From the intersection on Axis II of a line between $F = 40$ and $Q = 0.01$, draw a line through the BCD point of line M to Axis I. The point where the line from $P = 2$ through the turning point on Axis I intersects line B indicates the average BCD brightness which in this case is about 1500 footlamberts. In other words, if the brightness of the source is 1500 footlamberts, approximately half of a large group of individuals will find the sensation to be at or less than their own BCD value or to be in the comfort zone.

Example 3. At times it may be desirable to determine the brightness which will be at or near the BCD sensation for the most sensitive individual. Using the values of Example 2, but drawing the line from Axis II to Axis I through the lower limit of the BCD range, it is found that the source brightness must be reduced to about 550 footlamberts. In other words, if the brightness of the source is 550 footlamberts, it will be BCD or less for almost all who may view it.

Multiple Sources

With most lighting installations, the sensation of brightness is induced by more than one source in the visual field. Therefore, it is desirable to be able to determine relationships which can be used to establish the BCD brightnesses for multiple sources. The simplest approach is to determine the characteristics of two or more sources in terms of a single source which produces the same sensation of comfort or discomfort. Since light-sources usually are spaced symmetrically in a visual environment, it is possible to consider certain basic positions of the sources as being representative of more complex arrangements.

The standard experimental conditions were used in this phase of the investigation. That is, the comparison-source subtended a solid angle of 0.0011 steradian at a viewing distance of 40 inches and the field brightness was 10 footlamberts. In the two parts of this investigation the test-sources were one-half the area and equal to the area of the comparison-source, respectively. The comparison method was used to determine the BCD brightnesses of the test-sources.

Additive Effect of Different Areas of Equal Brightness. In this part of the investigation two test-sources were located on a horizontal plane equidistant from the comparison-source which was on the line of vision. Each test-source subtended one-half the solid angle of the comparison-source, or 0.00055 steradian (1.045 inches diameter). The subject was required to adjust the brightness of the two test-sources until the sensation produced by them was equal to the sensation produced by the single comparison-source. The general arrangement is illustrated in Fig. 14 for (I) when the fixation point was coincident with the comparison-source and (II) when the fixation point was 20 degrees below the comparison-source.

When the comparison-source C was on the line of vision, it was set at the standard BCD brightness of 830 footlamberts. The test-sources T were used in pairs, both of which were simultaneously exposed. For example, test-sources were located 10 degrees to the right of and 10 degrees to the left of the com-

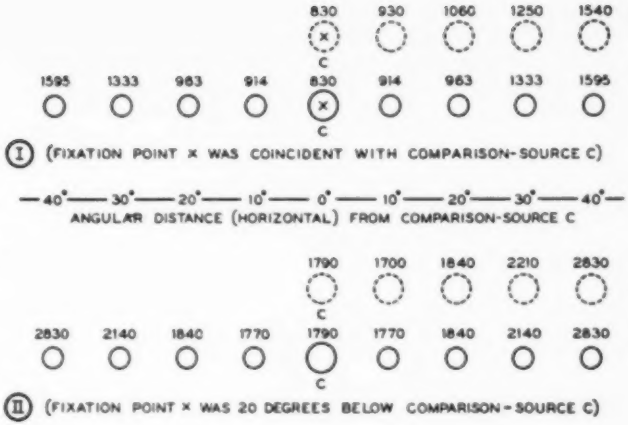

830 930 1060 1250 1540
C
1595 1333 983 914 830 914 963 1333 1595
C
I (FIXATION POINT × WAS COINCIDENT WITH COMPARISON-SOURCE C)
— 40° — 30° — 20° — 10° — 0° — 10° — 20° — 30° — 40° —
ANGULAR DISTANCE (HORIZONTAL) FROM COMPARISON-SOURCE C
1790 1700 1840 2210 2830
C
2830 2140 1840 1770 1790 1770 1840 2140 2830
C
II (FIXATION POINT × WAS 20 DEGREES BELOW COMPARISON-SOURCE C)

Figure 14. The BCD brightnesses of pairs of half-area test-sources (0.00055 steradian) as compared with full-area sources (0.0011 steradian) for two experimental conditions. The BCD brightnesses for a field brightness of 10 footlamberts are indicated above the circles.

parison-source and were seen by averted vision. The two test-sources and the comparison-source were exposed alternately for 1-second intervals.

In I, Fig. 14, the average BCD brightness of two half-area sources displaced equal distances horizontally from the comparison-source are indicated above the solid circles. The BCD brightnesses of the single full-area source, indicated above the dotted circles, were obtained from the curve for horizontal displacements of Fig. 7. It is seen that the BCD brightness of the two half-area sources are approximately the same as the BCD brightnesses of a full-area source displaced the same distance from the line of vision, with an average variation of approximately 5 per cent.

When the fixation point was 20 degrees below the comparison-source, the predetermined brightness of the latter was 1790 footlamberts (from the curve for vertical displacement, Fig. 7). In this case all the sources were seen by averted vision. The BCD brightnesses of the half-area sources are indicated above the solid circles. The BCD brightnesses of the single full-area sources were obtained from Fig. 9. The BCD brightnesses of full- and half-area sources are approximately the same, the average variation being about two per cent.

From the data on half-area sources it may be concluded that two sources of equal brightness and area located symmetrically on either side of the line of vision are equivalent to a single source of the same brightness and total area located at the point where one of the half-area sources is located.

Additive Effect of Sources of Equal Area and Brightness. In Fig. 15 are presented the BCD brightnesses of multiple sources located at various angular distances above the line of vision. Standard experimental conditions were used. That is, the sizes of the test- and comparison-sources were 0.0011 steradian, the brightness of the surrounding field was 10 footlamberts and the brightness of the comparison test-source was 830 footlamberts. From one to four test-sources were exposed simultaneously and alternately with the comparison-source. For example, with Condition V test-sources were located at angular distances of 10, 20 and 30 degrees above

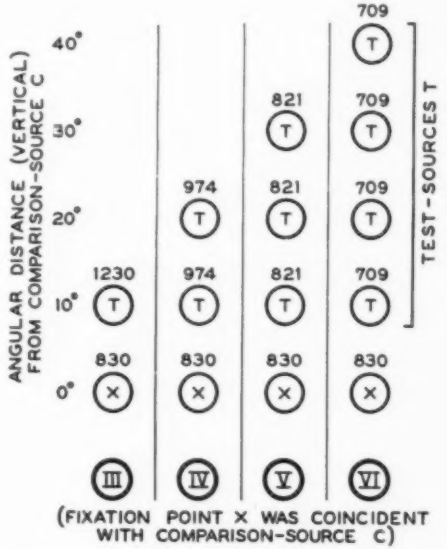


Figure 15. The BCD brightnesses of multiple test-sources *T* located above the line of vision. The size of the sources was 0.0011 steradian and the field brightness was 10 footlamberts. The point of fixation "X" was coincident with the comparison-source *C*.

the line of vision. The subjects were required to evaluate the initial momentary visual sensation induced simultaneously by the three test-sources and adjust their brightnesses so that the sensation was equal to that induced by the comparison-source which was coincident with the point of fixation. Similar evaluations were made with Conditions III, IV and VI except that one, two and four test-sources were involved, respectively. Since the comparison-source was set at the BCD brightness, the brightnesses of the multiple sources also were BCD values. The average BCD brightnesses as determined by the group of representative subjects are indicated directly above the circles which represent the sources.

As additional sources are added above the line of vision, the brightnesses of all the sources must be reduced in order to maintain the sensation at BCD. When the sources are progressively added at greater angles above the line of vision, the necessary reduction in brightness becomes progressively less. This is to be expected, since, from Fig. 7, it is seen that for the same sensation, sources displaced at greater angles from the line of vision may be considerably brighter than sources closer to the line of vision. Thus, the source displaced the smallest angular distance from the line of vision contributes more to the sensation than do the other sources.

By means of the nomogram of Fig. 12 it is possible to calculate the size or position of a single source above the line of vision having the same brightness and producing the same sensation as the multiple sources. For example, the two sources of Condition IV are located at 10 and 20 degrees and the average angle is 15 degrees above the line of vision. Thus, using a source brightness B of 974 footlamberts, a position index P of 1.79, a field brightness F of 10 footlamberts and M equal to the average BCD value, the corresponding value of the size Q of the source is 0.0044 steradian. Alternately, if the size Q of the single source is assumed to be equal to the sum of the areas of the two test-sources, or 0.0022 steradian, the position index obtained from the nomogram is 1.39. From Fig. 11 this may be converted into a vertical displacement of slightly more than 8 degrees. In other words, the two test-sources may be represented by either one of two single sources: (a) by one which is four times the area of a single source located at the average angle above the line of vision; or (b) by one which is the sum of the individual areas (0.0022 steradian) and located approximately at the position of the source that is closest to the line of vision.

Three sources above the line of vision (Fig. 15, Condition V) may be represented by (a) a single source of ten times the area (0.011 steradian) of each of the multiple sources located at the average angle of 20 degrees above the line of vision or by (b) a single source of three times the area (0.0033 steradian) of the multiple sources located eight degrees above the line of vision. Calculations of the single source which is equivalent to four sources above the line of vision (Fig. 15, Condition VI) result in (a) a source of 0.024 steradian located 25 degrees above the line of vision or (b) a source of 0.0044 steradian (the sum of the four individual solid angles) located approximately seven degrees above the line of vision. From the foregoing it is seen that a simple and practical equivalent for multiple sources of equal brightness and area which are located above the line of vision is the total of the individual areas located at the position of the source that is closest to the line of vision. Such a conclusion appears to be a conservative one.

The results of a similar investigation of sources located to one side of the comparison-source when the fixation point was 20 degrees below the comparison source are presented in Fig. 16. It is seen that as additional test-sources T are added at greater angles from the comparison-source C, the brightnesses for the BCD sensation become progressively less. Since both vertical and horizontal components are involved in defining the positions of these sources in the visual field, the determination of a single equivalent source becomes considerably more complex. However, the test-sources T of Conditions VIII, IX and X may be represented by single

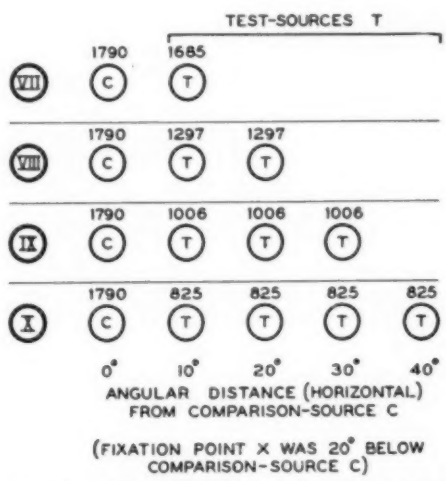


Figure 16. The BCD brightnesses of multiple test-sources located above and to the right of the line of vision. The size of the sources was 0.0011 steradian and the field brightness was 10 footlamberts. The point of fixation "X" was 20 degrees below the comparison-source C.

sources located at average angles to one side of the comparison-source *C*. The brightnesses of the single sources are the same as the respective multiple sources. For example, for Condition VIII a single source located midway between the two test-sources could subtend a solid angle of 0.0030 steradian, which is approximately three times the area of each test-source. The three test-sources of Condition IX may be represented by a single source located 20 degrees to the right of the comparison-source *C* and which subtends a solid angle of 0.0068 steradian or about six times the size of each test-source. Similarly, a single source subtending a solid angle of 0.0135 steradian located 25 degrees to the right of the comparison-source *C* will be equivalent to the four test-sources *T* of Condition X.

It has been emphasized that values of *M* other than the average, minimum or maximum values have no absolute significance. Therefore, calculation of *M* merely results in a numerical index of the sensation of comfort or discomfort of the brightnesses within a visual environment. Values of *M* are not directly additive. That is, if a group of multiple sources is collectively at the average BCD brightness, the sum of the individual *M* values does not necessarily equal the average value of 108. In general the sum will be higher than the average value. Calculations based upon the individual sources illustrated in Figs. 15 and 16 result in summations ranging from about 140 to 175, with a maximum individual *M* of approximately 80. A tentative conclusion, which must be substantiated by additional experimental data, is that if the sum of the *M* values of the individual sources of a group is not more than 150, and if the *M* value of any single source is less than 80, the sensation induced by the group of sources probably will be at or less than the BCD sensation.

Linear Sources

Since many lighting installations involve fluorescent lamps and lighting equipments which present areas that are relatively long and narrow, it is desirable to establish the relationships between circular and linear sources. Thus the basic relationships between the factors which influence the degree of sensation induced by a circular source can be applied with reasonable accuracy to sources of certain other configurations.

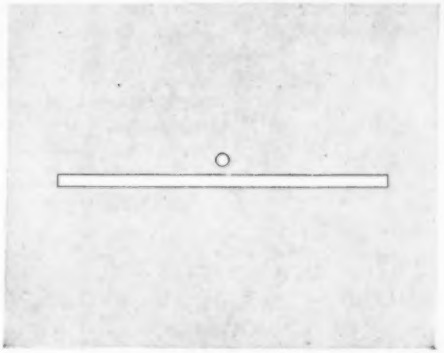


Figure 17. The arrangement for determining the BCD brightness of linear sources. Each source was alternately viewed directly by the subjects. The diameter of the circular source was 1.48 inches, approximately the same as the diameter of the tube of the 40-watt lamp which was used as the linear source. The viewing distance was 10 feet and the field brightness was 10 footlamberts.

In this part of the investigation the circular source was located immediately above the linear source as is illustrated in Fig. 17. The two sources were close to the line of vision and therefore each could be fixated directly with a minimum movement of the eyes. The brightness of the surrounding field amidst which the sources were viewed was 10 footlamberts. The diameter of the circular source was 1.48 inches, approximately the same as the diameter of the tube of a 40-watt fluorescent lamp which was used as the linear source. At the viewing distance of 10 feet, the circular source subtended a solid angle of 0.00012 steradian which is within the range of sizes used in the basic phase of the present investigation.

TABLE V.—BCD brightnesses in footlamberts for equal areas of circular and linear sources, for a viewing distance of 10 feet and a field brightness of 10 footlamberts. The linear source was actually a 40-watt fluorescent lamp (1.5-inch diameter).

Area of Sources Square Inches	Circular Source		Linear Source		BCD Ratio Lin./Cir.
	Diameter Inches	BCD Brightness Footlamberts	Length Inches	BCD Brightness Footlamberts	
0.78	1	2000	0.52	2000	1.00
3.14	2	1340	2.10	1340	1.00
7.07	3	1040	4.71	1070	1.03
12.6	4	880	8.40	940	1.07
19.6	5	770	13.1	855	1.11
28.3	6	685	18.9	805	1.18
38.5	7	625	25.7	775	1.24
50.2	8	575	33.4	760	1.32
63.6	9	535	42.5	750	1.40
78.6	10	500	52.4*	740*	1.48
113.	12	445	75.3*	735*	1.65

*Extrapolated.

The comparison method was used, the linear source being considered the comparison-source. The brightness of the circular source was adjusted by the subject until the initial momentary sensation induced alternately by the two sources was identical. The experimental variables included the length and brightness of the linear source. Thus, with the basic data for circular sources it was possible to determine the BCD brightnesses of linear sources of various lengths.

In Table V are summarized the BCD brightnesses for equal areas of circular and linear sources. The BCD brightnesses are approximately equal for both types of sources for areas not greater than about 7 square inches when viewed at a distance of ten feet. However, as the area of the source is increased beyond 7 square inches, the permissible brightness for the BCD sensation for the circular source becomes progressively less than the BCD brightness of the linear source. In other words, as a linear source begins to deviate from a concentrated area, adding to its horizontal length does not require much of a decrease in its brightness in order to maintain a BCD sensation. Apparently if the length of a linear source is less than approximately four times its width, it may be considered equivalent to a circular source.

In the present investigation it was found that the 40-watt fluorescent lamp at the normal lamp brightness of 1610 footlamberts produced the same sensation as a circular source 1.48 inches in diameter and a brightness of 3000 footlamberts when both were viewed directly at a distance of 10 feet. From the nomogram of Fig. 12 it is determined that this circular source must be positioned above the line of vision in order for the sensation to be at the BCD level. The position index P is 1.8 which indicates, for example, that the source should be located approximately 15 degrees above the line of vision.

Summary

A complex subject such as quality of lighting cannot be resolved into a simple summary. In reality, this paper is a summary of an extensive series of researches dealing with the complex relationships among the various factors which govern whether a visual environment is comfortable or uncomfortable. These factors are divided into two groups. The first group involves those that are basic and fundamental such as:

1. The brightness of the source or luminous area.
2. The visual size of the source.
3. The brightness of the surrounding field.

The relationships among these factors have been determined by evaluating them in terms of a visual sensation which is at the borderline between comfort and discomfort. We have termed this the BCD sensation or BCD brightness.

Certain other factors which have a modifying influence upon the basic factors include:

1. The position of the source in the visual field.
2. The number of sources in the visual field.
3. The configuration of the sources.

By combining the effects of the modifying factors with the basic relationships, it has been possible to devise a nomogram and a disk calculator which simplify the determination of the brightness conditions which should produce an average BCD sensation or BCD brightness.

Glimpses have been given of the manner by which the basic and modifying data may be practicalized and rationalized with lighting practice. Because of the limitation of space, it is necessary to postpone to a future paper a discussion of researches involving critical seeing, continuous exposure of sources, distraction thresholds, simulated practical visual environments, etc. Considerable data already have been obtained on these, and a thorough analysis should materially assist in further practicalization of the fundamental relationships.

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DISCUSSION

LELAND H. BROWN:* I consider this paper an outstanding piece of engineering research in the field of brightness studies. Direct engineering application of their findings is assured for they chose as the criterion for their studies the "BCD sensation." By fixing the source diameter and brightness of the field they were able to first establish a standard BCD brightness. Then by varying one factor at a time, and keeping everything else constant, they determined the BCD brightness for: different field brightnesses, different source sizes, different source positions in the visual field, multiple sources, and linear sources.

The data they secured for all these different conditions are all quite consistent and conclusive. They consequently constitute excellent engineering material for use in lighting applications. However, after accumulating these results, the authors summarized their findings by mathematical equations and then prepared an alignment chart and a calculator to enable one to calculate the BCD brightnesses for combination conditions. Presumably such calculations are justified, but to be conclusive more data than the two meager spot checks for 1 and 100 foot-lamberts shown in Fig. 4 should be given if engineers are to use the chart or calculator with confidence.

In researches such as this one it is always difficult to get a group of "typical" observers. It would therefore be very interesting, and helpful to future researchers, if the authors would state just which of subjects 1 to 50 made up the 10-man group that was used for most of the tests.

The authors carefully point out that their studies, as reported in this paper, only cover the BCD brightnesses for a source, or for sources, exposed momentarily to a person's view. However, they added that they had similar studies underway covering continuous exposures of sources, etc. Illuminating engineers will await their completion of these studies and the publication of the results with keen anticipation.

WARD HARRISON:** Much appreciation is due the authors who have today brought us data which are new and badly needed. In fact, the test information is so voluminous and so diversified that it is difficult to present an adequate discussion of the paper and at the same time be brief. I would like to emphasize just a few points which seem to me most significant, and of course I shall be particularly interested to compare the authors' results with appraisals according to the glare factor method.

1. It should be kept in mind that the BCD represents the point where half of the observers feel that the glare source is on the comfortable side, and the other half think it is on the uncomfortable side. The authors established BCD values for sources from 6 inches in diameter to 36 inches viewed at a distance of 10 feet. These same BCD figure out to have glare factors ranging from 22½ to 40, and represent a very good agreement with Mr. Meaker's description*** of glare factors of this magnitude, which I quote:

15-25 Some people will find such rooms slightly annoying, particularly when they are engaged in critical work for long periods. This range is usually satisfactory where the occupants are changing activities and position at intervals of an hour or so.

25-40 This range should not be exceeded where quality of lighting is a consideration, in rooms where critical work is being done. Such values are illustrated by large rooms indirectly lighted to 75 footcandles or more in which some persons are persistently conscious of the large ceiling area.

2. In Mr. Holladay's work published in 1927 he found an exponent for Q of $-.25$ with relation to B. In the glare factor formula an exponent of $-.5$ has been used for Q, which indicates an apparent discrepancy of serious magnitude. It happens, however, that the largest glare source used in the Holladay experiments had an area of .006 steradians (approximately a 10-inch globe viewed at a distance of 10 feet); Luckiesh and Guth have most commendably carried the work on up to 0.126 steradians, or an area of about 30 times the former size. They check Holladay's experiments quite well for sources of the small area which he investigated (here they find B varies as Q $-.3$) but their results are quite different for larger sizes. They have developed a formula:

$$B = 296Q^{-0.21} - 377$$

which covers the entire range of their work, but the "-377" has such powerful effect on the final results that it renders the fundamental relationships difficult to visualize. A simple equation which satisfied quite well the new data for the larger area is:

$$B = 27Q^{-.6}$$

As a matter of fact, this equation fits all the points from .01 up as far as 0.1 steradians, with a maximum error of not more than 7%. Likewise, the equation

$$B = 39.3Q^{-.5}$$

checks the Luckiesh-Guth data very well from .006 (the largest area tested by Holladay) to .06 steradians with about the same margin of error. In the opinion of the writer, areas of these general magnitudes are the ones of real importance in lighting practice—that is, they are representative of the sum total area of light sources usually found in modern lighting installations, particularly

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***ILLUMINATING ENGINEERING, July, 1949, p. 404.

those of the fluorescent type. For these areas it will be noted that there is a very good check between the BCD-method exponents and the exponent of −.5 used in the glare factor formula.

An exponent of −.25 as found in the range explored by Holladay would mean that doubling the brightness of a source was as bad from the discomfort standpoint as increasing its area 16 times, whereas an exponent of −.5 means that doubling the brightness is only as bad as increasing the area four times. Much of the I.E.S. recommended practice has been based on the former concept, namely, that brightness is all important and that brightness limitations or brightness contrast limitations alone are sufficient to assure comfort. The new data confirm the long-standing opinion of some of us that both brightness and area must be included in any reasonable recommended practice limitations.

3. It is noteworthy that throughout the important range from .006 up, light source area is of greater importance to comfort than is surround brightness—that is, the exponents for Q are higher than for F. In other words, when the number of light sources in a room is doubled, comfort will be decreased—not increased.

4. The data in Figure 14 for light sources placed 10°, 20° or 30° on either side of the line of vision are of particular interest, and from these data the authors draw the conclusion that the glare effect of two small sources equally removed on both sides of the line of sight is the same as for one source of the same total area at the same angle. This would seem to give corroboration to the idea that the glare effect of multiple light sources is additive directly, as is done in the glare factor formula. On the other hand, in VIII, Figure 16, where the light sources are not symmetrically arranged, their effect appears to be no longer directly additive.

5. Again, it is possible that the shock method of appraisal employed by Luckiesh and Guth may unduly penalize light sources at wide angles to the line of vision, for the eye is notably sensitive to moving objects and flashing lights near the periphery of vision.

6. The data on lineal *vs* circular sources are interesting indeed, and somewhat puzzling, particularly the very slight effect on glare of increasing the length of the fluorescent source beyond 10° on each side of the line of sight (21 inches at 10 feet). However, there seems to be certain corroboration of this in data which I saw last year in Holland which indicated a 4-foot fluorescent lamp viewed in its entirety was less discomforting than when the area of visible source was reduced to one-half by covering each alternate inch with a strip of opaque paper. This whole matter has far-reaching implications and raises numerous questions to be answered. For example, are continuous rows of fluorescent fixtures less glaring than interrupted rows, and how far can the space be between luminous areas of adjacent fixtures before they are considered discontinuous? Also, will the fluorescent fixture with luminous side panels four inches high have the same effect placed in continuous rows as will bare fluorescent lamps? In view of the great volume of helpful data already supplied, I hesitate to suggest it, but it would seem that these questions cannot be answered fully without still more laboratory investigation.

H. L. Logan:* Permit me to congratulate the authors on a splendid piece of work. It is a painstaking, careful, intelligent, ingenious and logical exploration of some of the response phenomena of human beings exposed to visual stimuli. It is research in an area that has been crying for such exploration. Dependable quantitative data such as the authors offer has been too generally absent.

A proper evaluation of this research will require a lot of time. It is something I would not attempt, upon such brief acquaintance. The paper offers many ramifying possibilities, both of application and of further research, and will unquestionably influence future practice for the better.

Offhand, the data would not seem to support the advocates of rigid, or very limited, so-called brightness-ratios. It also indirectly challenges—and this time with impressive evidence—the dictum first published in the *Journal of the Optical Society of America* in April, 1926, "that the angle of orientation of the glare source about the visual axis makes no difference in the glare effect." It would be extremely interesting to see what results the authors would get if they would carry their research into that part of the visual field that lies below the line of sight. They might find definite evidence to support the conclusion of lay people that glare is more "glaring" below the line of sight than above. Such evidence would be helpful in a rational attack on reflected glare.

The very completeness and thoroughness of the research, and its implementation with the "BCD Calculator," may cause many people to regard it as the final word. It is the *latest* word, but the authors are very careful to point out that it is a long way from being the final word. They state that they still expect to report on effects of continuous exposure to sources, to distraction thresholds, to simulated practical visual environments, and perhaps to color; all of which factors must then be integrated into a unified treatment before more than tentative practical applications can be made. This is a very ambitious, albeit necessary program, and one can only wish the authors "God-speed" in its execution.

The engineer is always under the temptation to take material of this kind and immediately use it, not only for all it is worth, but for more than it is worth. Scientists, like the authors, are the first to deprecate such "extrapolation." To guard against it they carefully state all the restrictions surrounding it, but the engineer, whose work will not wait, is inclined to disregard the limitations. This leads to delusionary conclusions; conclusions which may be true in the restricted laboratory sense, but are false-to-reality in their general application. The results of activity of this nature can be seen in installations all over the country. It has found expression in pronouncements of professional and industry committees that have even been incorporated into State and other Codes, thus freezing delusionary conclusions into law. This impedes progress in those areas until the laws can be ignored or changed.

It is to be hoped that the results of this research will

*Holophane Company, Inc., New York, N. Y.

not be clouded by such unwise and premature activity.

There is a long step, in this field of human response particularly, between laboratory data and practical application. Laboratory tests in this field must, by their very nature, be statistical. The use of small groups of observers (and groups of 10 and 50 are very small groups where human reactions are concerned), can only establish *trends* of interaction between stimulus and response. Further, the variables that must be controlled, or eliminated, in order to isolate one for test, sets up an artificial situation that cannot be translated, *a priori*, into the actual working and living situations of people. This may become possible when the statistical base becomes large enough, and this paper is a significant step in the right direction.

I appreciate the reasons that impelled the authors to build the paper around the term "brightness," but wish they could have found it possible to avoid this. Whenever they mention "brightness" they couple it with area and time, either explicitly or implicitly, and so they are actually talking about light flux. They know this but may believe they will only be understood if they continue the use of the ambiguous abstraction "brightness."

The fundamental drawback to the term is the unconscious belief of practically everybody that brightness has objective reality—in the words of the layman, that it is *real*. It may come as a shock to many to be told that brightness is a label for a creation of the mind, and does not exist outside of one's skin. Light flux exists independently of an observer, but brightness does not. It is an abstraction the mind makes as the result of evaluating one effect of a visual stimulus on the nervous system.

Another effect that the mind likewise abstracts it labels "color." Color, like brightness, has no existence outside of an observer. The "green" is not in the leaf; it is not even in the eye; it is in the mind—or, putting it into 1949 terms, it is an abstraction made in the supra-granular layer of the cortex of the brain, of nervous activity occurring at lower levels, which in turn is an abstraction of nervous activity occurring in the optical thalamus, which in its turn is an abstraction of nervous activity occurring in the retina, optic nerve, and in-between connections. It can also be triggered internally without the aid of an external visual stimulus, and so can brightness.

Other forms of life, that have a different nervous organization, will not see the "green" in the leaf. They will see something entirely different, depending upon the particular band of radiation they are equipped to handle, and the degree of simplicity or complexity of their nervous organizations. Their "brightness" responses will likewise be very different.

The partial lack of dependence of the response upon the stimulus, and the very indirect and complicated connection between the two, makes it undesirable to use a feature of the response as if it were a feature of the stimulus. Brightness is a response phenomenon. Its present use in engineering practice confuses two different levels of activity. It confuses the independent reality in the external world with the semantic symbol arising from internal nervous activity. This leads to delusionary conclusions, as before mentioned, and undesirable engineering practices. The authors are well aware of this, because, while talking brightness as if it were a feature of the stimulus they have actually operated with flux. They know what they are doing but so that everyone else can be just as clear about it, a re-statement of their work on the basis of terms that indubitably belong to the stimulus, and terms that indubitably belong to the response, would avoid infusing new life into long-standing confusions.

This is in no sense a criticism of the able research reported by the authors. We should, and do, welcome dependable quantitative data obtained through controlled researches such as this. There is no other way to supply a solid foundation of knowledge for the determination of optimal seeing conditions.

PHELPS MEAKER:* I am very much pleased to note that the authors have not limited their studies to just a single light source in the visual field, or to sources on the axis of vision. If one adopts the notion that fixation of the glare source should be made the basis for comfort evaluation, it follows that you can only look at one source at a time. However, in all the comparison tests, and the paper deals with many of them, the fixated source is limited to serving as a reference for comparison, by which other sources off the line of vision are given an equivalent evaluation.

Out of the 17 illustrations in the paper, nine of them deal exclusively with the concept that discomfort can result from sources which are not fixated, i.e., sources off the line of vision. Three of the remaining figures include reference to off-axis sources. Half of the tables are similarly devoted to positional data.

It is obvious that there may be any number of sources in the visual field, each of them an off-axis source, amenable to some sort of comfort or discomfort evaluation. To use the terms adopted by the authors, the BCD brightness of any group of sources depends upon the number and disposition of all of those which can affect the eyes. This conclusion is supported adequately by the results of their experiments dealing with multiple sources.

It is unfortunate that there was not room for more information on details of the additive evaluation of many sources in the visual field. Let us hope that the publication of this will not be delayed.

In the present initial phase it is right that there should be no numerical scale of answers on the nomogram and the disk calculator. The difficulty, however, is that to calculate M, in order to test out the tentative rule for multiple sources, one must wade through the cumbersome exponential formula. So far, the disk and nomogram put the spotlight on the single source, and this is perhaps regrettable. I believe it will be apparent to the careful reader of this paper that it is not enough to keep each individual source in an installation below BCD brightness. Perhaps we may tentatively suggest that each source should be well below the average BCD value in order to play safe.

MATTHEW LUCKIESH and S. K. GUTH:** We wish to thank the discussors for their complimentary remarks regarding our paper. However, several points have been

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raised which require clarification.

Mr. Brown wonders whether Fig. 4 is sufficiently conclusive to be used as the basis for the nomogram and calculator. The displacement of the curves for the three field brightnesses was obtained from the relationship illustrated in Fig. 2. The points on the curves of Fig. 4 represented by solid circles were established by *all* of the representative subjects. The parallelism of the curves was checked for the smallest and largest sources.

The selection of the representative subjects for the extensive series of tests was limited to those who would be readily available over an extended period of time. Those selected included Nos. 1 to 5, 8, and 10 to 13. It is interesting to note that the arithmetic and geometric mean BCD brightnesses of the standard source for this group are 896 and 839 footlamberts, respectively. Those values are almost identical to the average BCD brightnesses obtained by the 50 subjects.

Mr. Harrison has tried to simplify the formula which relates the size Q of a source and the BCD brightness B. Obviously a number of empirical equations can be made to fit the experimental data, especially if only a limited range of sizes is considered at one time. In this initial paper we have developed an equation which would include *all* of the experimental data and emphasize that this equation holds only for the range of data obtained. We believe that it is desirable to have a single equation for all sizes of sources rather than two or three different equations for certain ranges of sizes. The latter could result only in confusion. The complexity of the empirical formula should not be discouraging. The curves of Fig. 4 illustrate the relative and variable effectiveness of size of source and surrounding field brightness. Furthermore, the nomogram and disk calculator obviate the necessity for using the equation and simplify the calculations.

The use of the initial momentary sensation, controlled as to duration, should give a very real evaluation of light-sources at wide angles to the line of vision. It must be remembered that the eyes are seldom fixated upon a point for an extended period. The complete act of seeing involves continual shifting of the line of vision. As a result, peripheral sources of brightness are being "seen" by different retinal areas as the eyes fixate various objects. Thus, various retinal areas are receiving momentary stimuli of brightness. The dynamic technique used in our investigation actually may be resulting in a more accurate and practical evaluation of these sources than a static technique. Certainly our technique has the virture of control of exposure, and controls are essential to any researches of this character. However, a preliminary analysis of data using prolonged rather than momentary exposure of sources indicate BCD brightnesses of the same order as those presented in this paper.

The effect of increasing the length of linear sources should be evident from the data on multiple circular sources horizontally displaced from the line of vision which is illustrated in Fig. 16. The necessary reduction in the brightnesses of the sources to maintain the BCD sensation become progressively less as more sources are added at greater angles from the line of vision. A linear source is merely an extreme or limiting condition of the multiple sources where the sources are adjacent to each other. That portion of a source closest to the line of vision produces the greatest part of the sensation. The addition of equal incremental areas requires correspondingly less of a reduction in brightness to produce the BCD sensation.

In our paper we stated that space limitations made it necessary to postpone to a future paper a discussion of numerous additional results and analysis which make possible the correlation of the basic data with lighting practice. Included among these is a series of investigations of extended linear sources mentioned in the last paragraph of our paper. When we publish the results, they should materially fill the gap indicated by Mr. Harrison.

We have speculated upon the effect of sources of brightness located below the line of vision. It should be pointed out that the work of Holladay referred to by Mr. Logan involved the obscuring power of a dazzle-source and not the sensation of discomfort. In other words, Mr. Logan refers to that part of Holladay's investigations which pertained to what has been termed "disability glare" which does not necessarily correlate with "discomfort glare."

Fig. 9 of our paper should present a glimpse of the expected relative BCD brightness of sources below the line of vision. There is marked parallelism between the curve of equal BCD brightness and the curve representing the boundary of the upper half of the average visual field of subjects with normal vision. If this parallelism continues to hold in the lower portion of the visual field, the boundary curve in this region would indicate that a source below the line of vision would be more uncomfortable than a similar source located in the corresponding position above the line of vision.

Mr. Logan's brief discussion of stimulus versus response is interesting. However, it should be obvious that our results are presented in terms of the physical characteristics of a stimulus which produces a specific sensation or response. He may have preferred us to use "luminance" when referring to the photometric characteristic source or stimulus and "brightness" when referring to the sensation. The terminology used in the paper should be clear to everyone and we do not believe that there should be any confusion as to the meaning of any terms used. To this end, for example, we have avoided the use of the word "glare" which as commonly used is so generally not sufficiently clear or specific in meaning.

Further discussion of Dr. Luckiesh's and Mr. Guth's Conference paper, received too late for inclusion in this issue, will be published together with rebuttal in subsequent issues of ILLUMINATING ENGINEERING.

Discussion of other Conference papers, to be published with the papers, should be forwarded promptly to Hoyt P. Steele, Chairman of the Committee on Papers, c/o Benjamin Electric Mfg. Co., Des Plaines, Ill. A copy of the discussion should also be sent to the author.

Laundry Lighting Requirements

By A. W. KAKILTY

THE various members of the I.E.S. Committee on Residential Lighting have volunteered to further present studies or instigate new ones on the lighting of various ordinary activities and areas of the modern residence. Many of these subjects have been so taken for granted that actual definite information is strangely lacking, or else the advance in the art and science of lighting practice has been so rapid that actual use of the product has outstripped technical investigation. Test work of this type resolves itself into preliminary investigations the main purpose of which is to pose certain questions and suggest additional avenues of research. At best, such results indicate what may be expected by employing certain typical lamps and luminaires in normally accepted locations.

Test Area

Originally it was decided to construct a 9-foot by 12-foot test room to be set up like a laundry. However, a very gracious offer of the use of the already completely equipped laundry in the Pittsburgh addition of the Blandings' Dream House in which any type of test could be conducted, quickly decided the issue. Statistics of this room are as follows:

Room is approximately 15 feet in length by 8 feet in width with a 7-foot 5-inch ceiling. The reflection factor of the ceiling is 77 per cent and that of the sidewall 51 per cent. An automatic washer together with a laundry sink and work surfaces are along one wall while situated along the other wall is a freezer unit the top of which was used as a clothes sorting table. At one end is a flat plate ironer. Normally, the room is lighted by means of three 4-foot fluorescent fixtures butted together in a straight line. These fixtures are ceiling mounted and are of a type having glass sidewalls and glass bottom. Fig. 1 is an illustration showing the laundry room. Each of the three sections is fitted with three 40-watt white lamps giving a total of 9 lamps at 360 watts.

General Lighting

The lighting in most residential laundry areas or utility rooms is not "laid out," it "grows." Incidentally some of this isn't so bad since the householder usually puts a lamp where he needs it. However, when the room is laid out, it may be done in one of three ways which we here illustrate.

1. It could be bare lamps, possibly placed in the four corners of the room as indicated in Fig. 2.
2. Four two tube fluorescent units of the type as shown in place for test purposes in Fig. 3 would possibly be used.
3. We may also have the attractive layout as was actually done with the three units in a row as indicated in Fig. 1.

Of course, other possibilities are numberless, but these are three typical cases.

The results of test No. 1 with four bare lamps are indicated in Fig. 4 which indicates the individual footcandle readings averaging 20.5. That, in itself means little except that attention is directed toward the various footcandle levels at the parts at which the housewife will work, namely:

1.	At the ironer	23.5
2.	At the sink	12.0
3.	At the washer	14.5
4.	At sorting table	8.5

True, these particular units may have been lo-

Figure 1. Laundry in "Blandings' Dream House."

A paper presented at the National Technical Conference of the Illuminating Engineering Society held September 20-23, 1949, French Lick, Indiana. Author: Director, Technical Service, Residential Sales Dept., Duquesne Light Co., Pittsburgh, Pa.

Figure 2. Bare Lamps in corners of laundry.

cated any place else in the room, but the point is, they weren't.

Fig. 5 shows the chart of footcandle readings taken with fluorescent units located in the four corners of the room. Here the average is 26.5 footcandles. Here again we have this condition. Note, louvered units were used instead of the glass bottomed units actually installed. No attempt is made, of course, to compare lighting outputs.

1. At the ironer	25.5
2. At the sink	11.5
3. At the washer	17.5
4. At sorting table	8.5

The regular lighting of the Blandings' Dream House Laundry is shown in Fig. 6. The average indicated is 43 footcandles with:

1. At the ironer	40.0
2. At the sink	41.5
3. At the washer	43.0
4. At sorting table	35.5

Since so many variables are involved, there is no intent here to compare average footcandles or the footcandles at one point in one system with those in a second system. The point being made is that here are three possible "layouts" in only one of

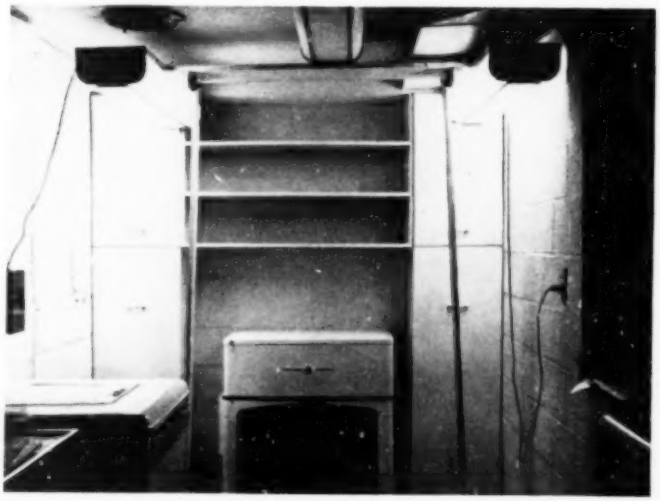


Figure 3. Test unit in place.

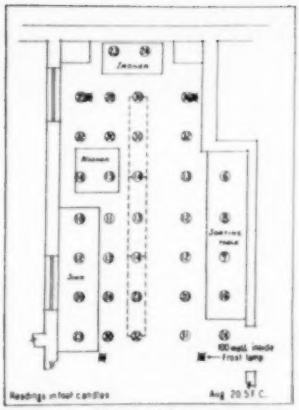


Figure 4. Chart of bare lamp test.

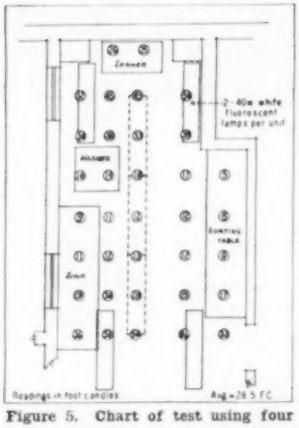


Figure 5. Chart of test using four fluorescent units, one in each corner of laundry.

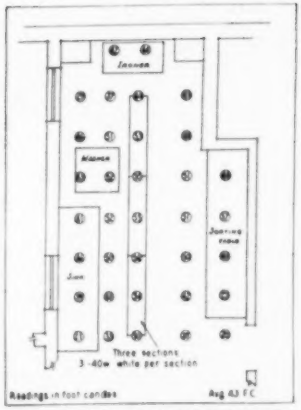


Figure 6. Chart of test using regular layout of laundry.

which is there as much light at most of the working centers as the average of the entire room.

Working Centers

As was discovered last year in the kitchen survey, the actual apparent illumination on any working area in these residential centers of operation is not what it seems. For in almost every case the operator gets right in his or her own shadow. An exaggerated illustration of this is given in Fig. 7. In the best apparent arrangement, that of Blandings' House (actual lighting layout indicated on the chart in Fig. 6) an illumination reading at the loading point of this washer showed 48 footcandles. Yet, when the operator stepped up to place clothes in the washer, the level dropped to 20 footcandles. Even with this excellent layout only half the light was usable. The comparison, of course, would have been even more marked in these instances:

1. Had the walls and ceiling been very dark and dingy and no reflected light returned to the top of the washer.
2. If the source of light had been less diffusing.
3. If the source was one small unit only; such as a bare lamp unfortunately located just behind the operator (as was actually the case when the photo was taken).

The washer represented a typical working spot. On the ironing plate one reading of 31 footcandles dropped to 16 when the operator actually sat down to start work. At the dial of the automatic washer 19 footcandles dropped to 10 when the worker stepped up and in the loading position on the vertical face of the dryer 11 footcandles dropped to 7.

Figure 7. With ordinary lighting layout, operator casts a shadow on laundry devices.

Illumination Required

There has been much discussion pro and con regarding just how much light is required for various operations. Probably the right answer to that is really—"As much light of the right quality as you can get," because we all know the story of young eyes vs old eyes and surely, in the home, both types of eyes have many seeing tasks to perform.

With the Luckiesh-Moss Visibility Meter the boys making this test (who, incidentally claim they are not yet "middle aged") undertook to survey the various tasks in the home laundry. The modern home laundry has become an attractive room, it is mechanized, and some new seeing tasks have entered

the picture. For example, now the housewife must read dials which must, by the way, be lighted in the vertical plane.

Operating independently several observers reached their own conclusions relative to the lighting leads required for each task. Of course, this gives one considerable latitude. He must decide for himself—(a) just what constitutes the task and (b) just how much light constitutes the minimum necessary amount. Of course, results were calibrated and we attempted to be quite technical but still there was considerable latitude for personal opinion, ideas, and imagination.

Some of the averaged results are as follows:

1. Loading an automatic washer (top or front loading is still a loading job and requires similar seeing effort; the only problem being to get the necessary light on the task) required 5.1 footcandles.

2. Sorting clothes was merely the rather mechanical task of unscrambling them and does not take into consideration looking for tears, or hunting missing jewelry that perhaps dropped down the laundry chute. This apparently requires 6.2 footcandles.

3. Setting dials on automatic devices includes a multitude of possibilities as to types of dials, how close you may have to read them, where you really view them from, etc. The observers decided upon 27 footcandles.

4. Ironing on an automatic flat plate ironer involving just the plain mechanical operation (with no close work on tucks, stitches, or small buttons) required 9.3 footcandles.

The consideration of the last item, ironing, immediately posed a number of additional queries. How about fatigue? This brought up the question of close observation and the color of light.

Color of Light

A space was prepared at the sorting table with a lighting unit overhead. A sample of white clothes was then scorched "lightly" with a hand iron and a second sample scorched "heavily" with the iron. These were to be tested by the visibility meter under various types and colors of illuminants as indicated in Fig. 8.

The average footcandles selected are those indicated in Table I.

TABLE I

Illuminant	Footcandles: Lightly Scorched Cloth	Heavily Scorched Cloth	Average
1. 100 watt Daylight Incandescent	47.5	15.0	31.2
2. 100 watt Inside Frost Incandescent	58.5	23.0	40.8
3. 2-40 watt Fluorescent (warm tinted)	82.5	27.5	55.0
4. 2-40 watt Fluorescent (4500° White)	90.0	25.0	57.5
5. 2-40 watt Fluorescent (Soft White)	102.5	31.5	67.0
6. 2-40 watt Fluorescent (Daylight)	102.5	32.5	67.5
7. 2-40 watt Fluorescent (White)	105.0	46.0	75.5

Figure 8. Visibility readings on scorched samples of cloth.

Although there are many variables involved, this survey would seem to indicate that the type and quality of luminaires and light sources as well as color characteristics have considerable effect on seeing certain items. On the other hand, this particular investigator did not posses the facilities to go deeply into the color situation. It is worthy of serious attention, however.

Conclusions

In this preliminary study of lighting in the residential laundry area (or utility room) some indications are apparent:

1. As is the case in most lighting problems, the walls and the ceiling should be very light in tone. In fact, in most cases this is the only way that illumination reaches the operator's side of the laundry device.

2. Since most laundry ceilings are low, all lighting equipment should be close-ceiling mounted; or if wall conditions do not interfere and plumbing is not a factor wall mounting is sometimes an advantage.

3. To avoid harsh shadows cast by the operator, all lighting should be exceptionally well diffused. Under some local conditions, wall mounting is advisable.

4. Although for appearance sake some typical standard layout may be followed, still, basically, this is not the best practice since in practically every case the light is on the wrong side of the operator.

5. Our laundry seeing is done by eyes of all ages. While it is true that an observer "got by" in very casually sorting clothes with 6.2 footcandles still that was mere "threshold seeing" even to him and his were young eyes. The mere dumping of clothes in an automatic washer required a very minimum of 5.1 footcandles. It would seem reasonable to set as a standard then for "good" minimum over-all lighting a level of 10 footcandles.

6. At specific locations where more careful work is done this level should be increased. Today the laundry is not what it used to be and (as our visibility meter survey showed) one job may now be reading dials on automatic machines. This required an absolute minimum of 27 footcandles. But today the most important seeing task is likely to be painstaking ironing operations. True, our investigation showed for mere seeing only 9.3 footcandles required on a flat-plate ironer.

But mere seeing isn't sufficient. This was our original reason for becoming interested in "light scorching"; and it will be noted that on these, visibility readings (without becoming involved in the color question) ran from 47.5 to 105 footcandles. This is surely an indicator that 10 footcandles is not sufficient where careful observation is necessary.

It will be remembered that in kitchen lighting we recommended 40 footcandles for particular locations. It would, therefore, seem that for careful ironing, it would not be amiss to recommend an absolute minimum of 40 over the entire working plane of the ironing board or of the ironer.

7. The color of illuminant question encountered would indicate that further study should be instituted under proper test conditions to determine whether or not considerable advantage would be attained by recommending definite color characteristics for lamps located over ironing areas.

Acknowledgements

The author wishes to express special thanks to Mr. W. B. Dixon, Jr., builder of Blandings' Dream House for his permission to use the laundry of this house to conduct all experiments.

Test units were furnished by Pittsburgh Reflector Company. Tests were conducted by J. E. King and William Lamb. Charts by J. A. McConnell. Photos by Jos. LaRosa.

DISCUSSION

E. D. ALTREE:* Considering the importance and number of home laundries, it is rather surprising that so little attention has been given to the lighting of them. To date, most of the research in the home lighting field has been done by the lamp companies and carried to the housewife by the utility Home Lighting Advisors. The Committee on Residence Lighting has done well to focus attention on this subject by selecting it for this program.

Electrical appliances have done a great deal to reduce laundry drudgery, but the first one, the electric lamp, is still not very effectively used.

Washday has been widely labeled "Blue Monday" and the actual and mental gloom that is usually associated with it could be appreciably dispelled if the characteristic "gloomination" were supplanted with illumination. For, as you all know, in addition to its ability to facilitate seeing, good lighting contributes to the creation of a pleasing atmosphere—and *this* is certainly a desirable attribute in the typical basement laundry.

In his conclusions, the author remarked that "in order to avoid harsh shadows cast by the operator, all lighting should be exceptionally well diffused." Everyone will agree with this recommendation and I wish to make the added observation that good diffusion is equally as necessary from the standpoint of reduced brightness contrast with the resulting improvement in visual comfort. From this point of view, the fluorescent lamps, whether shielded by louvers or further diffused by glass, are infinitely more desirable than incandescent lamps. Again, from the brightness contrast standpoint, the continuous assembly of three fluorescent luminaires is decidedly preferable to the corner arrangement of four individual ones.

H. G. CLUM:* This paper, together with several others on this and preceding convention programs, is an extension of the work of developing specific recommendations for home lighting. The conclusions reached in this paper represent a common sense appraisal of several methods of lighting a home laundry area. Unquestionably, there could be several other methods for the author has not by any means exhausted the possibilities of choice and placement of light sources and equipment.

The real significance of these and similar project studies in home lighting lies elsewhere. The very fact that such studies are being made indicates a more general consciousness that home lighting is one of the most intricate of all applied lighting fields. Under one small roof the range of lighting application is tremendous. There must be light for reading and study comparable in quantity and quality to that furnished for office or classroom; there must be light for household work comparable in many instances to the most critical conditions in industrial operations; and, finally, there must be light to satisfy aesthetic considerations which are as varied as the individuals involved. All of these, and many other requirements must be met with equipment and techniques which are much more intimate physically with the user than those normally used in commercial or industrial practice.

These detailed studies, therefore, are an expression of a growing consciousness of the intricacies of the home lighting field. Continued efforts in this direction may be expected to develop some rather precise lighting performance recommendations. Only when these are definitely established can we expect to give fixture manufac-

*Pittsburgh Reflector Co., Pittsburgh, Pa.

*Silvray Lighting, Inc., New York, N. Y.

turers an intelligible specification for the lighting element.

A. W. KAKILTY:* We wish to thank Mr. Altree very much for taking the time to read this paper as well as discuss it. As he points out, diffusion is exceedingly important, since it is only by this that we usually get any of the light at all at the points where it is most needed.

As was pointed out in presenting the paper, sometimes we no longer have definite rooms in the home. There may be no "dining room"; there may even not be a definite kitchen (as a unit area); there may be no basement; and there may be no laundry. But the same work is done in definite "areas" which are portions of other rooms. So we may have a washing "area" and somewhere else an ironing "area." Nevertheless, if we can determine definitely the best way to light each area and these results are published, then we have solved the problem of the laundry whether it be in one room or in several areas.

As Mr. Clum indicates, there is still much to be done in the field of home lighting and the Residence Lighting Committee is attempting to make a good start in establishing certain standards.

As pointed out, the present study is by no means exhaustive; in fact, it barely scratches the surface. However, if it can start things rolling toward the establishment of definite rules and regulations on what is good and what is bad, then it really will have been worthwhile. Everyone doesn't even have to believe all that is contained therein. Let them come forth with their ideas—only let them be constructive comments and ideas which (as Mr. Clum points out) can be passed on to the manufacturer so that he can do a proper job. More important still (or just as important) let them be something that we can take to Mr. Builder and Mrs. Housewife and say, "In this area you should do this!"

*Author.

Dual purpose soffit lighting in modern living room. The false bookshelf forms a soffit, in which are mounted two rows of two 42" slimline lamps in reflectors. One row lights the back wall and picture and the other is tilted to throw light on the book. Photo courtesy General Electric Co., Nela Park, Cleveland, Ohio.

Metal Reflector Coatings for Filament Lamps

By D. E. ELMENDORF
KIRK M. REID

Types of lamps incorporating metal reflecting surfaces are described, along with the principal metals useable in each case. Detailed data are presented comparing inside coatings of vaporized silver and aluminum, either of which can be used in blown-bulb lamps.

THERE ARE three main types of reflectorized lamps—(1) pressed-glass types known as PAR or sealed beam lamps, Fig. 1-A, (2) blown-bulb types with outside coatings, Fig. 1-B, and (3) blown-bulb types with inside coatings, Fig. 1-C.

All information reported on inside coatings is based on the product of one manufacturer.

Sealed Beam Lamps

In pressed-glass or sealed beam types of lamps the reflector and the lens are molded separately. A mold consists of a cavity and a plunger, between which the molten glass is pressed. Both inner and outer surfaces of lens and reflector are accurately controlled, with wide latitude in contours and configurations. During lamp assembly the lens is sealed to the reflector.

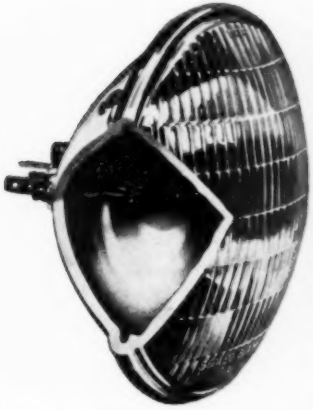
Pressed-glass types include headlamps, spotlamps, and foglamps for automobiles, spotlamps and floodlamps for general lighting service, headlamps for railway and mine locomotives, "slopeline" lamps for airport approaches, and many others.

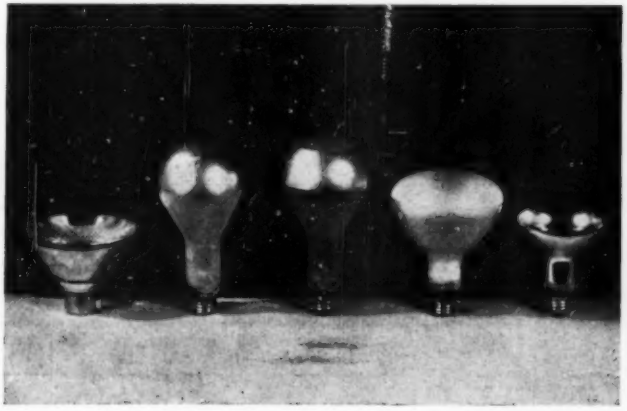
In some respects the pressed-glass types are the easiest to reflectorize, in other respects the hardest. The reflector has a wide opening, hence is readily accessible for cleaning prior to reflectorizing. The cleaner the glass the better the reflector surface. Two bulbs may be reflectorized simultaneously, face to face, with no subsequent processing needed. On the other hand, all these lamps employ borosilicate or heat-resistant glass and the temperature required for sealing lens to reflector is high. Further, the reflectorized surface comes very close to the sealing line. The high temperature of the sealing operation, necessarily carried on in open air, accelerates oxidation of the reflectorizing metal.

Aluminum withstands these abusive sealing conditions. In contrast, silver burns away near the seal, with attendant reduction in reflectorized area

A paper presented at the National Technical Conference of the Illuminating Engineering Society held September 20-23, 1949, at French Lick, Indiana. Authors: Lamp Development Laboratory and Engineering Division, respectively, General Electric Lamp Department, Cleveland, Ohio.

Figure 1-A. (Left) Cut-away view of sealed beam headlamp. Figure 1-B. (Right) Left to right: Projector floodlamp PAR38 side-prong base. Bowl-silvered lamp. Semi-silvered bowl lamp. Reflector floodlamp, R-40. Reflector spotlamp, R-30.





and also poor appearance. Other "white" metals such as tantalum, rhodium, or platinum may be used as vaporized inside coatings but do not have as high reflectance as silver. Further, there are greater variations in reflectance both initially and during lamp manufacture, and costs are high or application difficult or both.

Blown-Bulb Lamps with *Outside* Coatings

Blown bulbs are formed in a mold cavity by air pressure applied within a gob of molten glass. The glass is usually rotated within the mold during the blowing operation, hence the bulb wall is a substantially symmetrical surface of revolution. The outer surface is less accurately controlled than in pressed-glass techniques, and the inner surface differs from the outer only to the extent that the glass thickness may vary throughout the bulb.

Outside coatings are applied after the lamps are completed. This means that the light distribution of a high-production inexpensive lamp can be greatly altered to serve special purposes. For example, standard general lighting lamps may be bowl-silvered to provide efficient indirect lighting with simple fixtures. And many lamps, such as gunsight lamps, obtain their highly specialized beam characteristics by outside coatings accurately related to special bulb contours and source forms. These applications are described in detail in a previous paper.[1]

The largest processor of outside-coated lamps has found that best results are obtained by first applying a reflecting layer of silver. This is done from a chemical solution; to date, silver is the only "white" metal which can be so applied. There are two other steps necessary for suitable protection of the silver coating. A thin layer of copper is electroplated on the silver. Over this a special aluminum paint is sprayed and baked; it bonds with and protects the copper. The aluminum paint cannot be used directly on the silver since under the lamp operating temperatures it tends to alloy with the silver. The result is that the silver reflecting surface is likely to deteriorate before the end of lamp life. This outside-coating process has been highly mechanized, with attendant low costs.

An outstanding advantage of an outside coating is that it is possible to remove it mechanically to sharp lines, precisely positioned in relation to the filament. Further, coating configuration can be obtained which would be difficult or impossible with an inside coating.

Uniform application of silver or aluminum by vaporization for outside coatings is difficult and costly.

Blown-Bulb Lamps with *Inside* Coatings

In most lamps with inside-coated bulbs the reflectorized area of the bulb approaches a parabolic shape. Very few are true parabolas, the actual shape usually being adjusted to provide the beam characteristics desired with the filament source size necessary for the particular voltage and wattage. These coatings are used in bulbs covering a wide range in size, shape, and focal length; hence some bulbs are quite squatty while others are relatively elongated. Of these, the most popular is the R-40 bulb, 5 inches in diameter. Lately an R-30 bulb, 3¾ inches in diameter, has reappeared on the market and is rapidly gaining in popularity for the lower wattages. The R-40 bulb is used both in lime glass and borosilicate or heat-resistant glass. Lamps are made in the R-40 bulb for lighting service in both "spot" and "flood" beam spreads, and for infrared heating purposes.

Probably the earliest inside coatings were applied by a chemical deposition of silver. Such coatings on laboratory-made bulbs have shown at best a light

[1] "Application of Silver Processed Incandescent Lamps with Technical Data," by J. D. Whittaker, 1933 *I.E.S. Transactions*, p. 418.

TABLE I.—Comparison of Inside Coatings of Vaporized Silver and Aluminum in R-40 Reflector Lamps

Test Group	Lamp Watts	Beam Classification	Output Ratio, Silver to Aluminum			
			Total Lumens		Max. C.P.	
			Initial	700 Hrs.	Initial	700 Hrs.
		Laboratory and Pilot Plant Production				
1	150	Spot	1.11	*	*	*
2	"	"	1.12	1.06	*	*
3	"	"	1.17	*	1.17	*
4	"	"	1.17	*	1.11	1.04
5	150	Flood	1.13	*	*	*
6	"	"	1.16	*	1.22	1.23
7	300	Spot	1.15	1.12	*	*
8	"	"	1.17	*	1.20	*
9	"	"	1.17	*	1.20	1.18
		Regular Factory Production, Check Samples During 1948				
10	150	Spot	1.16	*	1.19	1.13

*No measurements made.

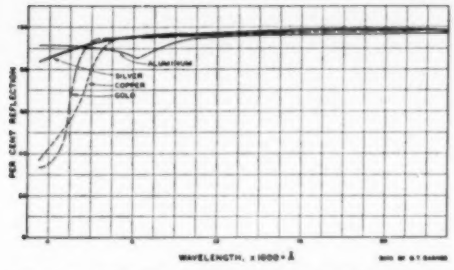


Figure 2. Reflection of front-surface mirrors freshly coated by evaporation in a highly evacuated bell jar.

output lower than that of vaporized silver, along with less uniformity and a tendency to become hazy during lamp manufacture. An important consideration is that in high production vaporized inside coatings can be applied for less cost.

For some years vaporized aluminum inside coatings were used. Aluminum is an easy metal to vaporize and forms a relatively good coating. Extremely high vacuum is not required; the metal has a fairly low melting point and good covering power in forming the reflector surface.

More recently, further work has resulted in the development of an efficient process for vaporizing silver, with techniques similar to those for aluminum. Table I shows that use of silver represents a gain in lumens and maximum candlepower of fully 10 to 15 per cent.

The variations in values in Table I are due for the most part to slight variations in frost density, and to improvement in reflectorizing techniques for the later lots in the pilot production. Data on lamps of 1948 factory production indicate better consistency, with values of lumens and maximum candlepower averaging throughout life approximately 15 per cent better for silver than for aluminum. Considerable effort has been expended in trying to produce aluminum reflectorized bulbs as good as the silver because of the lower cost of aluminum, but thus far the difference of 10 to 15 per cent exists.

The difference is still in favor of silver over aluminum, although to lesser degree, in lamps with lower color temperature designed for heating purposes where most of the radiation measured is in the infrared. Studies of surfaces of vaporized copper in heat lamps indicate a reflectance slightly better than aluminum, but below silver.

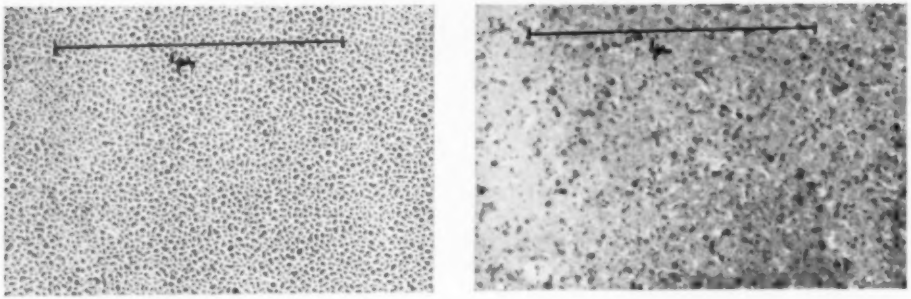
The curves in Fig. 2 would indicate that an increase in light output of only about 5 per cent might be expected due to use of silver rather than aluminum for inside-coated lamps. Why, then, do the values in Fig. 2 and Table I differ? Table II disposes of one possible explanation, by showing that both silver and aluminum go through the process of lamp making without significant change in reflectance. The difference is there immediately after reflectorizing.

The explanation appears to be that the samples in Fig. 2, in the form of flat plates, were made under optimum laboratory conditions. With the bulbs, however, after inside reflectorizing it is necessary to take a further step. The reflecting metal must be dissolved from the end of the bulb, through which the light is emitted in the finished lamp. This dissolving is done by means of chemical solutions, winding up with a thorough washing. It is almost impossible to tell directly whether the dissolving process seriously affects the reflectance of the remaining mirrored surfaces. Some attempt has been made to check this but the other conditions imposed have overshadowed the point being investigated. The results of the study might be summarized by saying that silver, under present production processes, more nearly approaches its maximum reflectance than does aluminum.

Another advantage of silver over aluminum is that once it is sealed off in the lamp it will withstand higher lamp operating temperatures than aluminum. This is a particularly important point in many reflector lamps where it is desired to concentrate as much wattage as possible in a given size of bulb. Any tendency for the reflector surface to deteriorate immediately raises the temperature of the surface and bulb at that point, causing further

TABLE II.—Comparison of R-40 Spotlamp Bulbs with Inside Coatings of Vaporized Silver and Aluminum, Before and After Lamp Making

	Total Lumens, with 60-Watt Test Lamp Inserted in Bulb			150-Watt Completed Lamp, Before Removing Bulb	
	Metal Freshly Vaporized	48 Hrs. Later	Bulb Removed from Completed Lamp	Total Lumens	Max. Beam C.P.
	Relative Output, Based on Fresh Aluminum as 100				
Aluminum	100	99	102	.....	.....
Silver	114	113	115	.....	.....
	Relative Output, Based on Aluminum as 100 in Each Case				
Aluminum	100	100	100	100	100
Silver	114	114	113	115	114



SILVER ALUMINUM

Figure 3. Surfaces of vaporized silver and aluminum, magnified 50,000 times.

deterioration and, in the extreme, even bulb blistering.

As a matter of interest, Fig. 3 shows the microstructure of vaporized silver and aluminum. The coatings were evaporated on a smooth surface and were of thickness less than that normally applied, in order to make it possible to obtain good micrographs directly. These pictures were taken with an electron microscope, and are here reproduced at a magnification of 50,000.

DISCUSSION

FRED J. VORLANDER:* I believe we all concur with the authors that silver coated reflectors are basically superior to aluminum reflectors in light reflection qualities. However, one of the prominent difficulties in the use of silver coated reflectors for lamps has been a tendency for the reflecting surface to oxidize or tarnish if allowed to stand unassembled for a short time after coating. Although this oxidization appears to have but a minor effect on the light reflecting qualities of the lamp, it does cause the lamp to have an undesirable appearance.

In this paper there was a comment that "the cleaner the glass, the better the reflector surface." We presume the authors are referring to the perfection of the coating which results, for it is known that any tendency for uncleanliness of the glass surface will result in pin holes in the aluminum or silver coating applied.

The authors in discussing the method of removing the unwanted reflecting metal from the end of the bulb by dissolving the metal coating with an acid commented that it is almost impossible to tell directly whether chemical dissolving processes seriously affect the reflectance of the remaining reflector. As the dissolving chemicals should never touch the reflecting surface that is to remain, it would appear that most any injury to the reflectance of the aluminum coating would be that caused by fumes of the dissolving chemicals affecting the reflector surface. It is, of course, possible for a very dilute solution of this chemical to touch the reflecting surfaces when the bulbs are being washed after being coated; however, this solution should then be so weak and the exposure time so short that the reflecting surface should not be harmed. I believe this point could stand clarification.

The authors comment on the ability of silver to withstand higher lamp operating temperatures than can be tolerated with aluminum. We have found that in high wattage reflector lamps any type of reflector surface blackens severely directly above the filament. Our experience with 500 watt R-40 lamps has also been that silver coatings will hold up where aluminum coatings burn off completely in spots above the filament. We have not, however, noticed any bulb blistering due to the heat accumulation which caused the failure of the coating.

*Commercial Engineering Dept., Champion Lamp Works, Lynn, Mass.

ERRATA

Duration and Intensity of Sunshine by Frank Benford, ILLUMINATING ENGINEERING July, 1949.

In Figure 46, page 389, the notations for the angles a_1 and a_2 should be interchanged.

Equation (60), page 394, should read $O = T \cot a_2$ instead of $O = T \tan a_2$.

Low Pressure Mercury Discharges

By GEORGE MEISTER
THOMAS H. HEINE

Fluorescent lamps are low pressure mercury discharge devices which depend upon the efficient production of ultraviolet radiation for their efficiency. In this paper the inert gases and mixtures thereof are investigated in the presence of mercury vapor and their effect on the ultraviolet efficiencies produced by these discharges is measured. Simultaneously the electrical characteristics, the visible ultraviolet and fluorescent efficiencies are obtained.

LOW PRESSURE mercury discharges are used extensively in fluorescent and bactericidal lamps. The electrical characteristics of such low pressure mercury discharges were previously reported by Marden and Meister.[1] Their results showed that, at a given lamp temperature, pressure and current, as the atomic weight of the inert gas increases, the voltage gradient in the mercury discharge and the voltage drop at the electrodes decrease.

The efficiency of a low pressure mercury discharge fluorescent lamp depends upon the mercury pressure and the wattage in the discharge. Marden, Beese and Meister[2] showed that at a constant bulb temperature and a given current the inert gas with the greater atomic weight and lower ionization potential has a better efficiency than an inert gas of lower atomic weight and higher ionization potential. Thus, of the gases tried krypton was better than argon or neon. Their efficiency and voltage data were recently confirmed by Found and Winninghoff[3] when they compared argon with krypton-filled fluorescent lamps.

The early data were all taken on the individual inert gases mixed with mercury except in one case where a 60 per cent neon 40 per cent argon mixture was tried. This mixture gave voltage values showing the effect of the presence of both inert gases. The following data contain further information on the use of mixtures of inert gases with mercury discharges.

Apparatus

In order to obtain as much information as possible on one experimental lamp a special tube was designed in which the central portion consisted of a 5-inch Vycor section of 1.5 inches inside diameter which was sealed to 1.5 inch diameter Pyrex at both ends. The Pyrex sections could be coated with phosphors. Auxiliary-heated oxide coated cathodes were used and spaced about 24 inches apart. In addition a water-jacket 3 inches in diameter was designed to fit around the lamp in which the central portion again was a 5-inch Vycor section sealed with white wax to Pyrex at each end (see Fig. 1). With this construction it was possible to measure the light output of the phosphors, the ultraviolet output of the arc discharge and the light output of the arc, at different gas pressures and controlled temperatures for various currents with corresponding voltages and watts input.

The assembled tube with coated phosphor sections was sealed onto an exhaust system which had

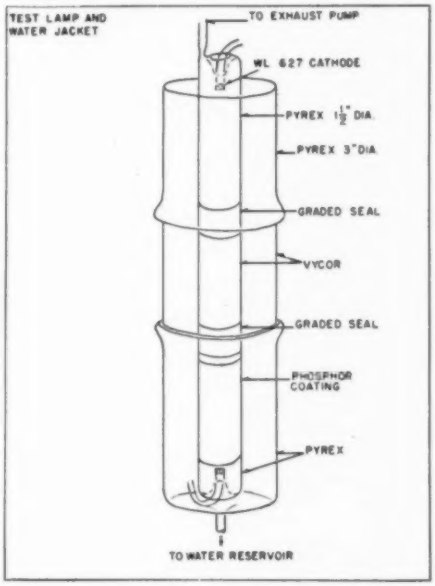


Figure 1.

A paper presented at the National Technical Conference of the Illuminating Engineering Society held September 20-23, 1949, French Lick, Indiana. Authors: Westinghouse Lamp Division, Bloomfield, N. J.

a cooling trap, surrounded with dry ice throughout the experiment. A liter reservoir for allowing proper diffusion of gas mixtures was provided into which could be introduced the spectroscopically pure inert gases, krypton, neon and argon. The system also was equipped with a McLeod gauge to read pressures.

The lamp was exhausted and baked at 475°C for about one hour. Also the cathodes were processed until no more gas was liberated. The water-jacket was put into place so that the Vycor sections of the jacket and lamp Vycor sections coincided and was firmly fastened to keep it in a fixed position. The annular space between the lamp and jacket could be flushed with water at any desired temperature, which was read on a thermometer placed in the water surrounding the lamp.

A voltage stabilizer was used to control the voltage input on the filament transformers, the discharge transformer and the ultraviolet meter.

The ultraviolet meter containing a tantalum cell to read the 2537A radiation was set in position opposite the Vycor section. The photovoltaic cells were placed in position opposite the Vycor section and the phosphor sections. They were checked before and after a set of readings with a standard incandescent lamp also using a voltage stabilizer in the circuit. All stands were securely fastened so as to keep all positions fixed during a run.

Experimental

The lamp was seasoned for several days before any readings were taken. This seasoning was done in mercury vapor alone continuously exhausting during entire period. During operation of the lamp, water was flushed up and down the tube until the temperature of the water was 45°C. All the data were subsequently taken at this temperature. The temperature was checked before and after each current reading. As each current setting was made, the ultraviolet output of the arc, the voltage, the visible light output of the arc, and the light output of the phosphor were read in that order. These zero gas pressure data were again obtained as a reference check after each change of inert gas or inert gas mixtures. After all the preliminary data were obtained then this lamp was operated at different inert gas pressures and mixtures of inert gases. The inert gases investigated were krypton, neon and argon and mixtures of krypton-argon and krypton-neon. These gas mixtures were varied so as to obtain sufficient data to show any difference in characteristics and each one was diffused at least 16 hours to insure uniform mixing.

The following mixtures were used:

I		II	
Krypton	Argon	Krypton	Neon
100%	0%	100%	0%
75	25	75	25
50	50	50	50
25	75	25	75
0	100	0	100

All the data presented in the accompanying composition curves are for a constant current of 500 milliamperes and a constant temperature of 45°C for different pressure parameters in millimeters.

Voltage Characteristics

In the voltage-composition curves at constant current and temperature for krypton-argon mixtures (Fig. 2) it is shown that the lowest voltage is obtained with 2 millimeters gas pressure throughout the entire range of compositions from 100 per cent krypton to 100 per cent argon. Since the voltage varies directly as the ionization potentials of the inert gases, krypton has a lower voltage than argon. Also there is a more or less linear relation with krypton-argon mixtures between 100 per cent krypton and 100 per cent argon. There appears to be a slight deviation from linearity as 100 per cent krypton is approached above 1 mm gas pressure. At 4 mm gas pressure voltage deviations from linearity are found at both pure krypton and pure argon.

In krypton-neon gas mixtures (Fig. 3) no such voltage linearity is observed between pure krypton and pure neon but instead the curves are concave

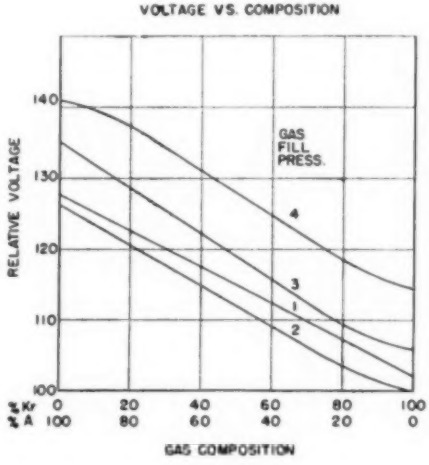
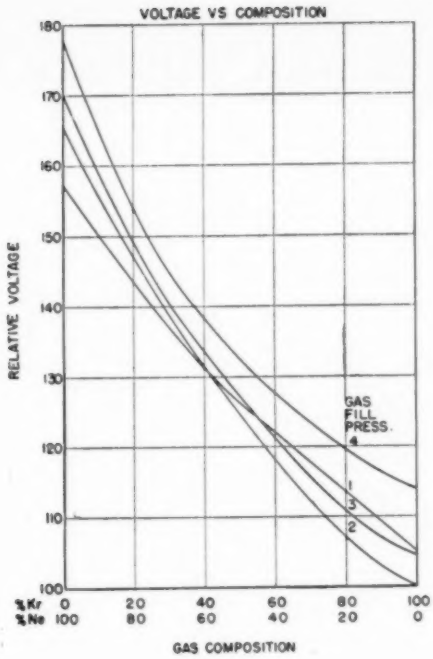


Figure 2.



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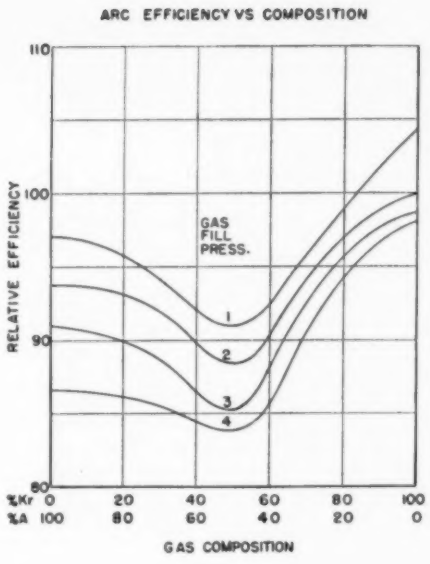


Figure 4.

upward for all pressures and are more or less parallel for 2, 3 and 4 mm pressure. The voltage again is lowest at 2 mm gas pressure for composition between 100 per cent and 40 per cent krypton. Beyond this composition to 100 per cent neon the curves cross and the lowest voltage is obtained with 1 mm gas pressure.

The voltage in the voltage curves is highest with neon. This result coincides with the fact that the ionization potential of the inert gases is higher for neon than for either argon or krypton.

Arc Characteristics

The arc efficiency-composition curves of the discharge at constant current and temperature for krypton-argon mixtures (Fig. 4) show a minimum in the visible light output at about 50 per cent krypton-50 per cent argon and the curves are more or less parallel for all pressures from 1 to 4 mm. However, while the voltage in the krypton-argon was lowest at 2 mm gas pressure it is seen that the visible light efficiency is highest for 1 mm gas pressure for all compositions between pure krypton and pure argon. Since it is known that at constant current and constant temperature and at a given pressure the voltage for krypton is lower than argon, it follows that the efficiency must be higher for pure krypton than for pure argon as can be observed in these curves.

With krypton-neon mixtures (Fig. 5) no such minimum is found but again the visible light effi-

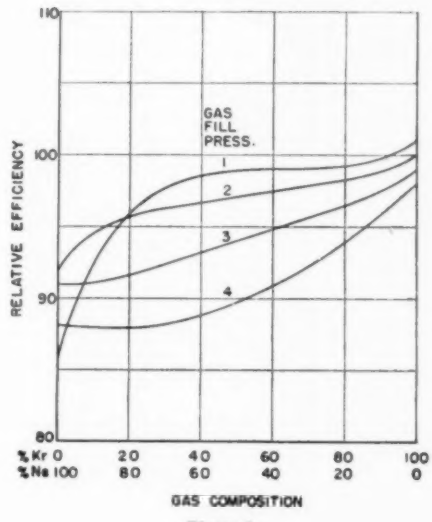


Figure 5.

ciency is greatest for 1 mm gas pressure from 100 per cent krypton to 20 per cent krypton-80 per cent neon. Beyond this point there is a steep decline in the arc efficiency so that at 100 per cent neon the arc efficiency is the lowest for all the pressures shown up to 4 mm gas pressure.

Ultraviolet Characteristics

The ultraviolet efficiency-composition curves at constant current and temperature for krypton-argon mixtures (Fig. 6) show a slight maximum at approximately 50 per cent krypton-50 per cent argon at 2 mm pressure but this maximum seems to shift slightly at higher pressures.

The highest ultraviolet efficiency is obtained at approximately 2 mm gas pressure for all compositions between pure krypton and pure argon. The ultraviolet efficiency is higher for pure krypton than for pure argon at all pressures. It is further to be noted that the ultraviolet efficiency decreases rather rapidly towards pure argon while only a slight decrease is observed towards pure krypton so that at 100 per cent krypton the ultraviolet efficiencies at 2, 3 and 4 mm gas pressure are relatively close.

In krypton-neon mixtures (Fig. 7) this maximum is more pronounced and occurs at about 75 per cent krypton-25 per cent neon at all four gas pressures. Again the ultraviolet efficiency is highest at approximately 2 mm gas pressure for all compositions between pure krypton and pure neon. The ultraviolet efficiency for pure krypton is greater than for pure neon at all pressures.

It is seen that the curves for 2, 3 and 4 mm pressures cross as they approach pure krypton. In this case the highest ultraviolet-efficiency appears to be at 3 mm. The reason is that the actual efficiencies are very close for this narrow pressure range.

Fluorescent Characteristics

The fluorescent output efficiency-composition curves at constant current and temperature for krypton-argon mixtures (Fig. 8) show a maximum efficiency at about 50 per cent krypton-50 per cent argon at 2 mm pressure. The highest fluorescent efficiency is obtained at 2 mm for all compositions between pure krypton and pure argon. This fluorescent efficiency at 2 mm pressure coincides reasonably well with the ultraviolet efficiency curve at 2 mm pressure. It is also seen that at this composition where the fluorescent efficiency is a maximum the visible light efficiency of the arc is a minimum (Fig. 4).

The fluorescent output efficiency-composition curves for krypton-neon mixtures (Fig. 9) have their maximum at approximately 75 per cent krypton-25 per cent neon. These curves again agree reasonably well at the maximum point with the ultraviolet-efficiency composition curves.

It is further to be noted that while the maxima in the ultraviolet and fluorescent efficiency for these inert gas mixtures all occur at about 2 mm

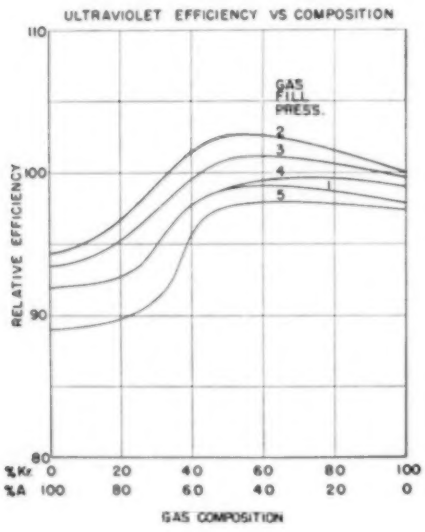
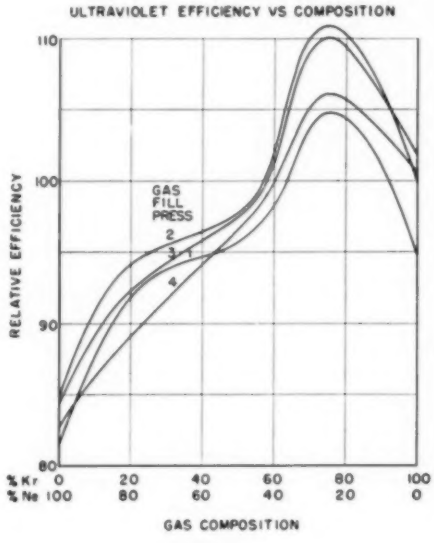


Figure 6.



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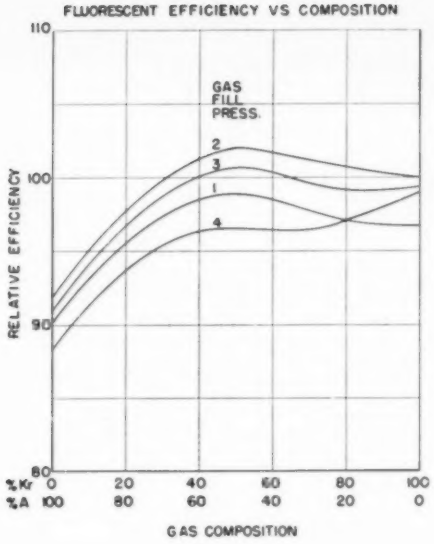

Figure 8.

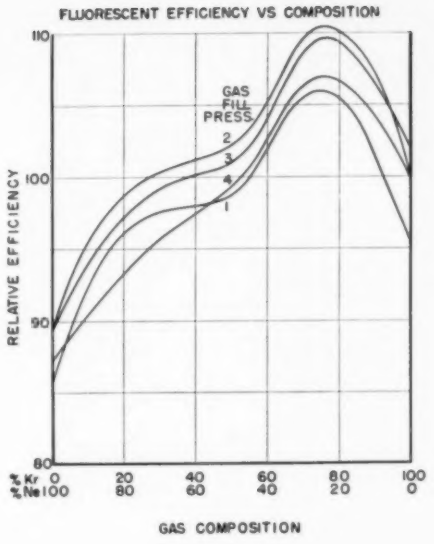

Figure 9.

gas pressure, the output efficiency of the arc for the krypton-argon and krypton-neon gas mixtures occur at 1 mm pressure. The only exception found was below 20 per cent krypton-80 per cent neon where the 1 mm curve crosses the 2 mm curve so that the arc, ultraviolet and fluorescent efficiencies from this composition to 100 per cent neon occur in the vicinity of 2 mm gas pressure. Thus the visible light output efficiency of the arc occurs at 1 mm gas pressure while the ultraviolet and corresponding fluorescent efficiency occur at 2 mm pressure exactly where the voltage of the experimental lamp is a minimum.

These data seem to indicate an optimum composition for inert gas mixtures where the ultraviolet production, mainly as mercury resonance radiation, is the most efficient.

An explanation for this result may be the presence of metastable atoms. Melville[4] has shown that the output of 2537A in a mercury-rare gas discharge depends upon the concentration of metastable inert gas atoms. His output curves for the inert gases have their maximum at about the same pressure as that at which the mean life of the metastable atoms is a maximum. He concluded that the collisions between metastable inert gas atoms and mercury atoms must be considerably greater than collisions between two inert gas atoms which cause the destruction of metastable states.

Lamp Engineering Tests

The above principles when applied to several well known krypton filled lamps alter the characteristics as shown in Table I.

TABLE I.

Lamp	Volts	Amps	Watts
25-watt Krypton	53	.52	25.0
25-watt Krypton-neon	59	.48	25.5
85-watt Krypton	57	1.60	85.0
85-watt Krypton-argon	62	1.50	90.0

The experimental results were obtained using separately heated cathodes by which part of the cathode losses were supplied but not counted against efficiency. Therefore, on practical lamps, in which the cathode losses are included, the efficiencies of the gas mixtures are less than the experimental curves show by an amount depending on the percentage of argon or neon added to krypton. However, the reduction is not great enough to overcome the increased efficiencies of the optimum mixtures, and efficiencies comparable to krypton lamps result. Other tests which will be reported in another paper also demonstrated a significant improvement in low temperature operation.

Conclusion

In this investigation of the krypton-argon and krypton-neon gas mixtures in the presence of mer-

cury vapor at low pressure (about 9 microns, corresponding to a wall temperature of 45°C) it was found that maximum ultraviolet and fluorescent output efficiency occurred at 2 mm pressure for a 50 per cent krypton-50 per cent argon mixture and for a 75 per cent krypton-25 per cent neon mixture.

The voltage of the lamp was lowest at 2 mm pressure for krypton, argon, krypton-argon, and krypton-neon, while for neon the low voltage occurs at 2 mm up to 40 per cent krypton-60 per cent neon but shifts to 1 mm from this composition to 100 per cent neon.

The arc efficiency for visible light was a maximum at 1 mm pressure for krypton, argon, krypton-argon, and krypton-neon and neon up to 20 per cent krypton and 80 per cent neon but from this composition to 100 per cent neon the arc efficiency was higher at 2 mm pressure.

With the 50 per cent krypton-50 per cent argon mixture there was a minimum in the arc efficiency-composition curve for all pressure parameters. No such minimum was observed in the krypton-neon series.

Commercial type F lamps corroborated these experimental data. In addition they show the decided advantage over pure krypton lamps of operating without striations at a lower ambient and bulb wall temperature.

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Nine and one-half miles of Highway 40 through Denver, Colorado are now lighted by mercury-vapor luminaires; 450 fixtures mounted 30 feet above the pavement on poles staggered at 110-foot intervals comprise the new installation which provides an over-all light intensity of about .7 footcandles average illumination. Characteristic of these fixtures is the blue-white light giving a well-lighted street surface and silhouetting objects in clear relief. Photo courtesy of General Electric Co., Schenectady, N. Y.

The Lighting Designer

By ABE FEDER

This article presents excerpts from an address given before the I.E.S. New York Section April 14, 1949, on the subject "Lighting and Architecture as Illustrated by the Terrace Plaza building in Cincinnati," by Abe Feder, Lighting Consultant of New York City.

IT'S ENCOURAGING to me that in the past five years people are beginning to realize the need for light design—and more and more they are understanding that light is not only an elusive, intangible thing — but something you can really feel — almost touch — and count when it comes to the times it has been used badly — or used correctly. Light is a tangible thing and it should be used architecturally to produce income and stimulate sales.

Lighting economics is like any other kind of economics. What you can get out of a job is the thing that determines in the long run what you can afford to put into it. One example is the tremendous part lighting plays in merchandising the Terrace Plaza Hotel. It actually "attracts" customers, in more ways than one. It will last for years and years, and make for more and more satisfied customers and therefore produce more and more sales.

If that kind of calculation is good economics in furnishing a hotel room or building a department store, or a hot dog stand, why isn't it good economics for the lighting that goes into such a structure? Now I'm not suggesting that the other kind of economics, the kind that is based on installation and operating costs should be ruled out. A lot of that kind of economics also went into lighting decisions in the Terrace Plaza Hotel.

Never let it be said that I didn't use every bit of lighting knowledge I had to save a legitimate dollar. But I consider that only part of the lighting job. It's the defensive side. What I'm most interested in is using lighting skill effectively to produce more dollars of income than could otherwise be produced.

That's the big new side of lighting. That's where a lighting designer comes in. That's where lighting design thinking is greater than common

MR. FEDER is a Lighting Consultant, New York, N. Y.

A general view of Cincinnati's Terrace Plaza Hotel, which occupies the upper eleven floors of a downtown business structure. "Moonlight" floodlighting of the terrace off the ninth floor lobby was accomplished by a battery of thirty 3000-watt reflector spot lamps mounted in ten groups of three and located 150 feet above on the nineteenth floor parapet for ease of maintenance.

A portion of the main dining room showing decorative general lighting created through the medium of a mural lighted by means of 150-watt reflector lamps mounted in vertical groups on facing columns. The recessed ceiling lights are typical of the ceiling lighting used for general service areas. Here in the dining room, the 150-watt reflector lamps in recessed louvered fixtures are subject to dimmer control

engineering practice which figures out the wiring and the power supply and the footcandles of illumination at "X" feet off the floor. That kind of a lighting job may solve the "seeing problem" and do it efficiently in terms of costs and optics and maybe even in terms of integrating the lighting with the general architectural form and design. But it won't do a thing about the all important aspect of the job — how people react to what they see.

And I want to emphasize that. We are not dealing with lighting equipment or lighting levels or lighting forms alone. We are dealing with people in relation to all those things. When you deal with the human equation you begin to find out that the standard formulas don't necessarily give you the right answers. Something new must be added—the insight and the instinct of the artist.

It's true that light bounces around, slips away and dissipates itself. But it's also true that light can be given form and substance. Take a shaft of light in a theatre. You can almost touch it. It's something in itself. And then take the reaction when a shaft of light hits some object. Whatever it is, it will burst into brilliance and seem to take on different physical properties and new emotional excitement.

This gives us something tangible to work with. It's done all the time on the stage where I had my fundamental training and early experience. But it can also be done outside the theatre in the commercial and social world. And it can be done with the same artistry that is used to bring illusion to the theatre audience. After all, every time you bring a lot of people to one place you have an audience. So the problem of making them see and feel what you want them to see and feel is the same basically, in the retail store as it is in the theatre.

There is literally an unlimited field for people who are really and truly thinkers and creators in light. People who recognize that working with light requires more than slide rules and light meters. I will admit that the technical side is always needed in the end to make a practical reality out of the things that the thinker in light has imagined. But what I want to impress on you here is that thinking in light is something essentially independent from the physical means of carrying out those ideas. Today we associate lighting with electricians and electrical engineers. What hap-

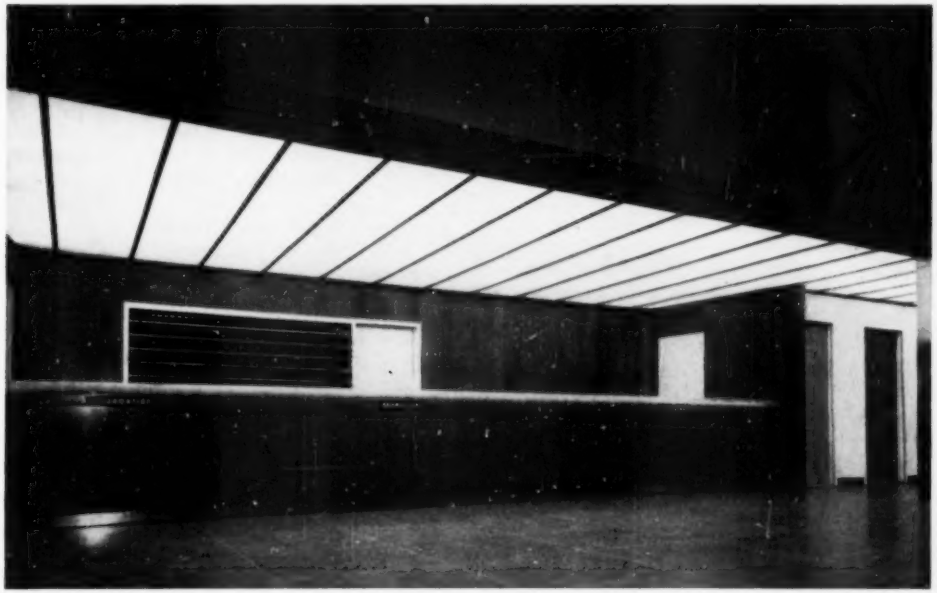
pens if tomorrow we should eliminate the wires and transmit energy with which to make light through the air? A new set of technicians would then have to be created. But for your lighting designer, your thinker in light, nothing will have changed. He will have gained one more means of giving reality to his thoughts and artistic conceptions. And the same thing would be true if some entirely new artificial light source were to be developed — some source that didn't use electricity at all.

When you think of light in this way, you are ready to accept the idea that lighting design really is and ought to be an independent field. It's something too important to be relegated to some subordinate on an engineering or an architectural firm's staff, or to someone who can be given a few objectives in terms of footcandles and wattage and told to draw in the necessary wiring on the plans.

That kind of an approach, however, is what we have had all too often in the past and, unfortunately, it looks as if some people are going to go right ahead thinking of lighting in those subordinate terms. I know of a 600-apartment unit planned for midtown Manhattan for which they are going about the lighting job in that way. They'll end up asking themselves, "What kind of fixtures can we buy to install the lights for so and so much money?" What they should be asking is: "What can we do with light to make this place more attractive and more livable? What are the human wants that light can fill to make this place more desirable?" Then, after they have answered a few questions along those lines, they should set out to develop lighting that will supply some of the answers.

That's the way the planning for the United Nations headquarters is being done. They're making provision right at the start, as to what they're going to do about light for television and photography. These are only two of the numerous functional needs that lighting will fill in that project, but I cite them as examples. We are working together to achieve a united result for the United Nations ... a unity of architectural form and light design. And we are doing it from the very beginning of the venture. As the UN planners are breaking new ground for new buildings, they are breaking new ground in architectural trends.

The Terrace Plaza Hotel in Cincinnati proved the value of coordinated planning in which lighting is given its rightful stature and authority. Thomas Emery Sons Inc. spent $450,000 to light that hotel — and in so doing they took a novel and progressive step by making lighting an integral part of the earliest plans for the project.



Terrace Plaza registration desk in the eighth floor lobby. A luminous ceiling provides a working level of 100 footcandles, using 156 slimline fluorescent lamps (52 96-inch and 104 64-inch) on nine inch centers.

Lighting of a Stairway

LIGHTING OBJECTIVE: To provide useful illumination for safe seeing conditions and to create a striking decorative effect enhancing architectural details.

General Information: This stairway rises from first floor foyer hall to second floor. Architecturally it is the focal point of interest as one enters the house. The walls are light beige with 75 per cent reflection factor; the carpet is medium beige with 35 per cent reflection factor; the floor is dark red glazed brick with 8 per cent reflection factor.

Installation
in the residence of
Mr. Jacques Makowsky
Great Neck, N. Y.
Architect: Edward D. Stone
Lighting Consultant:
Thomas Smith Kelly

Installation: Three lens type downlights are recessed in the ceiling of the second floor hall and are so placed as to give lighting coverage to the entire stairway. Each unit uses a 250-watt G-30 spotlight lamp.

Downlight designed by Thomas Smith Kelly and manufactured by Kliegl Bros., New York City.

Lighting data submitted by Thomas Smith Kelly, Lighting Consultant, New York City, as an illustration of good lighting practice and to aid in the design of similar installations.

Lighting data assembled by Subcommittee on Home Lighting Data Sheets and published by the Committee on Publications of the Illuminating Engineering Society, 51 Madison Avenue, New York 10, New York.

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Lighting For Flour Mills

Foreword

This report is the result of a study made during 1946-47 by a subcommittee of the Committee on Lighting in the Work World. The project included surveys of existing flour mills and trial installations.

SUBCOMMITTEE ON LIGHTING IN FLOUR MILLS

B. R. BUNN, *Chairman*
F. G. HAGADORN
A. B. HALLAWAY
J. M. HOUCK

1. Introduction

1.1—Need for this Study—In flour mill design there has been little regard given to adequate illumination. In the past the practice has been to rely on natural daylight entering through small windows and drop cords with bare filament lamps. The resultant illumination of from less than one footcandle to as much as five footcandles in some inspection areas adjacent to the equipment is entirely inadequate for the visual tasks performed during the 24-hour day that most mills operate. As a consequence, it is frequently necessary in the inspection of the flour for the operator to go to the nearest source of additional illumination, and in judging the samples most operators rely to a large degree on a sense of feel. However, the investigation upon which this report is based showed that where illumination has been installed in sufficient quantity, these same operators are more secure in their judgment of the material when they can give it visual examination.

1.2—Summary of Work of the Committee—**(a)** The suggested arrangement of luminaires (shown in Fig. 2) for roll floors was arrived at after experimentation with various other positions of lighting equipment in a flour mill. This study, conducted in cooperation with mill personnel, included the trial of 3500K white, 4500K white, soft white, and daylight fluorescent and standard filament lamps over a twelve-month period. Daylight (6500K) proved to be the preferred color of illumination for inspection of grain in process of milling.

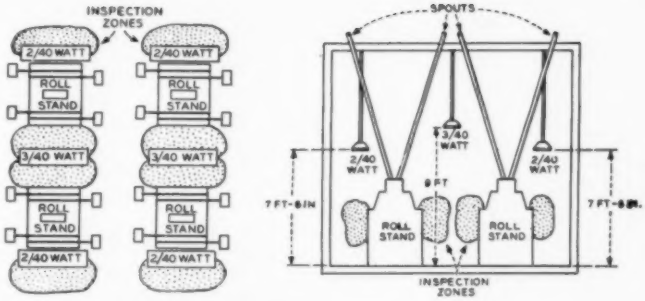
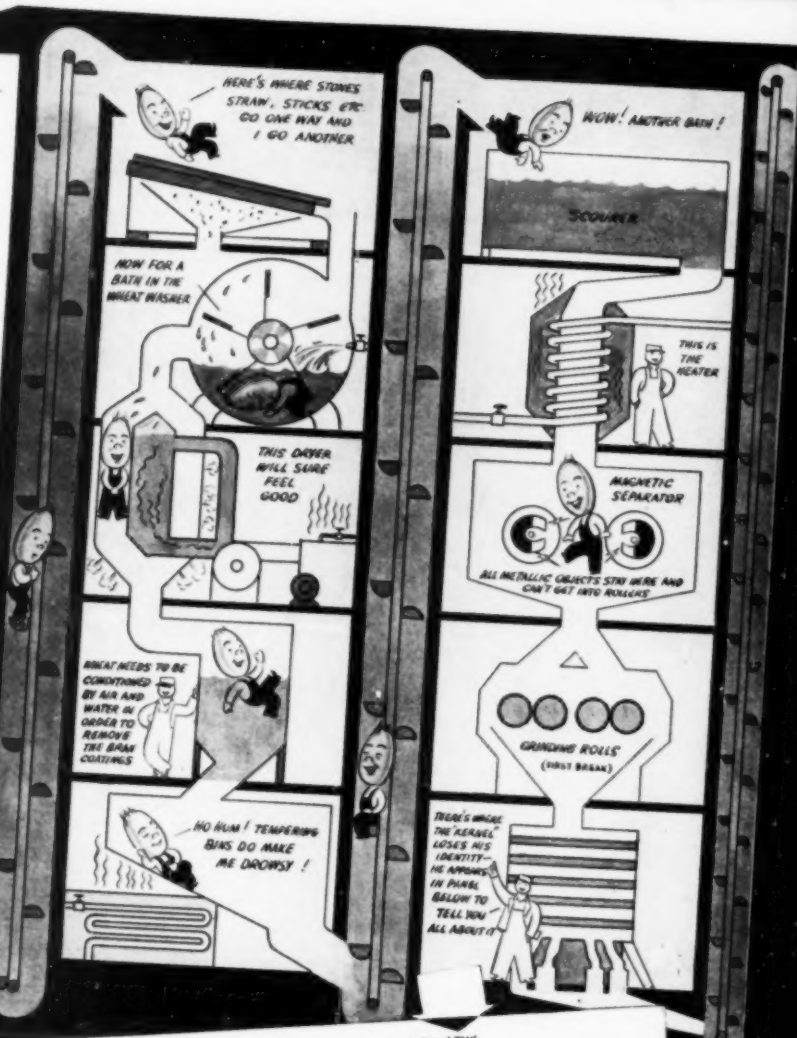


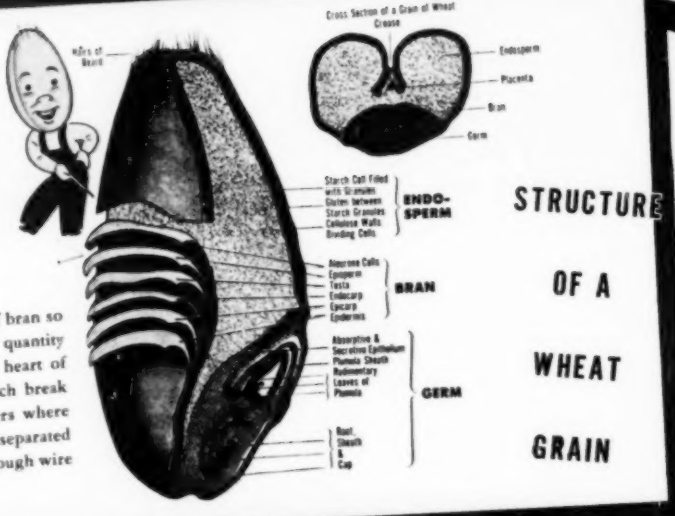
Figure 2. Above—Recommended arrangement of luminaires for roll floor plan shown at left and elevation plan shown at right.

Figure 3. Arrangement of roll machinery on typical roll floor. Upper left—Inspection of stock entering the rolls. Lower right—Inspection of stock after grinding.

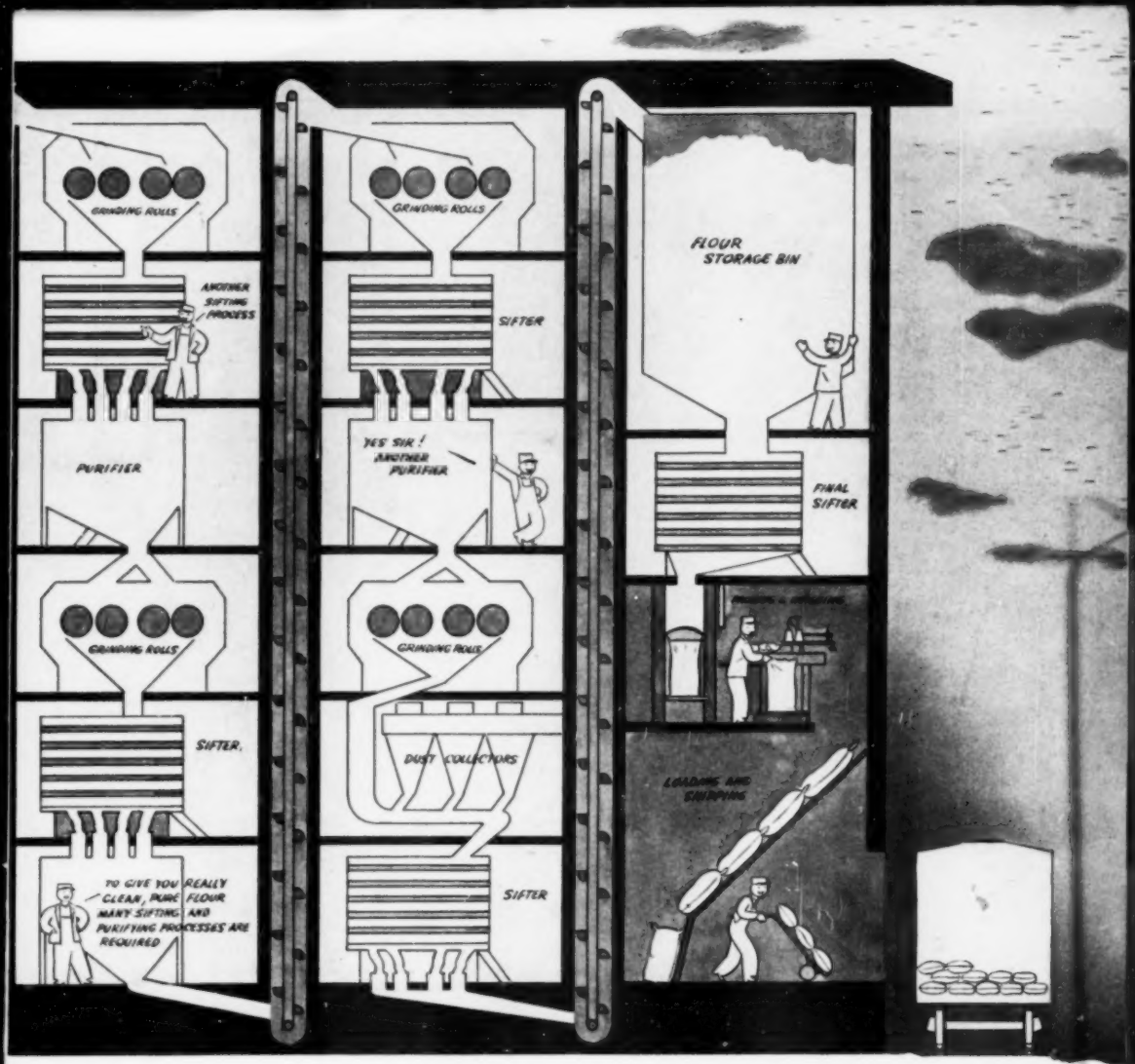
SECTIONAL VIEW OF A SIMPLIFIED FLOUR MILL


HERE'S WHERE STONES STRAW, STICKS ETC GO ONE WAY AND I GO ANOTHER
NOW FOR A BATH IN THE WHEAT WASHER
THIS DRYER WILL SURE FEEL GOOD
WHEAT NEEDS TO BE CONDITIONED BY AIR AND WATER IN ORDER TO REMOVE THE BRAN COATINGS
HO HUM ! TEMPERING BINS DO MAKE ME DROWSY !
WOW! ANOTHER BATH !
SCOURER
THIS IS THE HEATER
MAGNETIC SEPARATOR
ALL METALLIC OBJECTS STAY HERE AND CAN'T GET INTO ROLLERS
GRINDING ROLLS
(FIRST BREAK)
THERE'S WHERE THE "KERNEL" LOSES HIS IDENTITY— HE APPEARS IN PANEL BELOW TO TELL YOU ALL ABOUT IT

All of the operations up to this point in the above diagram are in preparation for the actual grinding and sifting processes. The wheat must be clean — it must be properly tempered to produce the finest flour. The purpose of the complicated milling process is to gently break the wheat berry and separate its outer coating of bran so as to produce the greatest quantity of purified middlings (the heart of the wheat berry). After each break the stock goes to the sifters where the purified middlings are separated from the rest by sifting through wire and silk sieves.



STRUCTURE OF A WHEAT GRAIN



LIGHTING IS IMPORTANT IN FLOUR MILLING

Obtaining the Finest Flour . . .

from raw wheat is a tedious, painstaking operation. The complex structure of a wheat kernel, as shown at left, necessitates several special operations to insure procurement of the purest finished product.

For processing into Bran and Standard Middlings, the outer coatings must be separated from the endosperm. The first bran layer, or epidermis, is a coating so fine it is often called "bee's wings" by millers. Removing these coverings also prevents small particles of woody, fibrous material finding their way to the finished flour. The short, fine hairs at the upper end of the kernel are earlier eliminated by scouring, washing and air pressure.

The germ, located at the lower end of the wheat berry, provides seed for the new plant. Separated from the rest of the wheat grain, purified and flattened between rolls, this portion produces Germ Middlings.

Note in the cross-section diagram that the wheat berry has a deep, narrow crease. While standing in the field, being stored and shipped, this crease collects dirt which must be removed before grinding begins.

Endosperm, from which the purified middlings and Patent flour are milled, constitutes four-fifths of the entire wheat kernel. Wholely free from foreign particles, and reduced to a uniform, desired fineness, this portion of the grain undergoes continued grinding and sifting before being packed as finished flour.

TABLE I.

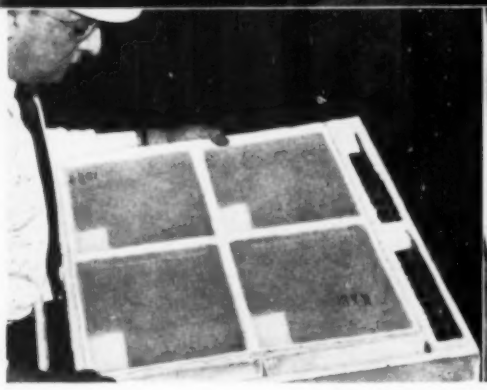
AREA	CURRENT RECOMMENDED PRACTICE: Level of Illumination Maintained in Service* (Footcandles)	CURRENT RECOMMENDED PRACTICE: Light Source (Color Temperature)
Roll Floor	40**	Daylight Lamps
Sifter Floor	40**	Daylight Lamps
Purifier Floor	40**	Daylight Lamps
Packing	30**	Daylight or White Lamps
Product Control Station	40**	Daylight Lamps
Offices and Laboratories	See "Recommended Practice of Office Lighting"†	
Miscellaneous (Cleaning Screens, Man Lifts, Aisleways and Walkways, Bin Inspection, etc.)	20**	Daylight or White Lamps

*These are the average lighting levels to which the installed system depreciates by normal collection of dirt and dust and lamp depreciation.

**All lighting equipment is to be of dust-tight design.

†Available at 50c per copy from Illuminating Engineering Society, 51 Madison Avenue, New York 10, New York.

Figure 4. Sifter floor showing typical sifting equipment with hand-hole inspection doors. At lower left, miller is shown examining sifter screen and at lower right, he is shown examining flour taken from sifter.



(b) These investigations show that most mills, particularly the older ones, have inadequate wiring as far as number of outlets and capacity to deliver sufficient electrical power for proper illumination levels are concerned.

(c) This report has been submitted to several prominent milling companies who have indicated concurrence with the recommendations.

2. Flow Chart

The pictorial flow chart shown on the preceding pages depicts the processing of grain into flour and serves to define the trade terms used in the report. This is a simplified flow chart only; it does not necessarily indicate the actual arrangement of the equipment.

3. Summary of Illumination Recommendations

3.1—Quantity—Table I giving recommended illumination is based on the combined results of a survey of current practice, visual task analysis, and trial installation.

3.2—Quality—Reflection factors of 75 per cent or higher are recommended for walls and ceilings, shaftings, etc. for adequate lighting and seeing. This value can be achieved with most semi-gloss white paints.

4. Analysis of Seeing Problems

4.1—Roll, Sifter, and Purifier Floor Inspection Areas—The inspection of the material in process is done by a combination of visual examination plus sense of feel. The material to be judged is usually examined in the hand of the operator. (See Figs. 3, 4 and 5.)

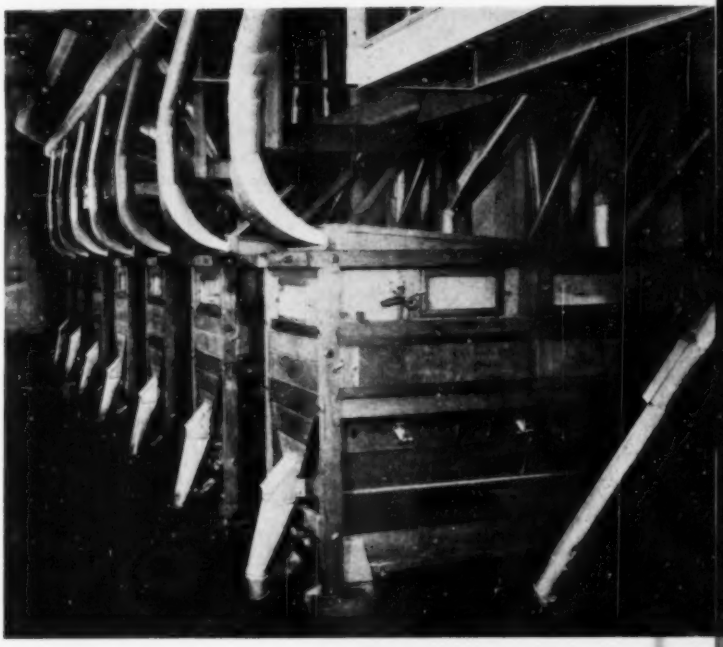


Figure 5. At right is shown typical purifier floor. Above is shown flour examination during purification which resembles that on roll and sifter floors.

4.1.1—*Rolls*—Fig. 3 shows the arrangement of rolls on a typical roll floor. The numerous obstructions above the equipment, visible in the photograph, do not seriously affect the proper installation of lighting equipment.

4.1.2—*Sifters*—Fig. 4 is a photograph of a typical installation of sifters. Note that the inspection points are in the discharge spouts at a position near the floor level.

4.1.3—*Purifiers*—A typical purifier equipment group is shown in Fig. 5 including the inspection operation.

4.2—Packing Areas—The seeing tasks in this area include reading small graduations on conventional industrial beam scales and the repetitive manual and visual operations involved in the filling and sewing of flour bags. See Figs. 7 and 8.

4.3—Product Control—Work in the product control station within the mill involves a seeing task comparable to that encountered on either the inspection points of the sifter and purifier or on the roll floors.

4.4—Miscellaneous Areas

4.4.1—*Critical*—require supplementary lighting

4.4.1.1—Inspection of material level in bins

4.4.1.2 — Examination of cleaning screens

4.4.1.3—Use of man lifts

4.4.2—*Non-critical*

4.4.2.1—Stairs

4.4.2.2—Aisles

4.4.2.3—Overhead runways.

5. Lighting for Specific Areas

5.1—General—All lighting equipment should meet the Underwriter's approval for use in Class 2, Group G locations. Such equipment will reduce the lighting maintenance problem involved from accumulation of dust, dirt and grease. It would be advisable for dust-tight equipment to be designed to deliver some upward lighting component for illumination of overhead line shafting, belting, etc.

5.2—Roll, Sifter, and Purifier Floors—**(a)** Levels of illumination in the range from 20 to 60 footcandles of various color qualities were studied in a mill. Soft-white was ruled out as a suitable color after a brief test, and white lamps (3500K and 4500K) were

Figure 6. Typical present practice for inspecting material level in bins. There is no fixture now designed or available which is entirely satisfactory for this location.

Figure 7. Flour bags are filled on the platform of a scale. The process is begun by machine, but the last few ounces are added by hand until the scale beam tilts. Once the scale is set for particular weight of bag, the visual task is non-critical.

each used for three months. However, it was unanimously agreed after six months' trial that 40 footcandles illumination from 6500K daylight fluorescent lamps provided the most satisfactory lighting for inspection purposes. The contrast between the flour and the impurities is higher under daylight quality of illumination.

(b) The use of fluorescent lighting equipment overcomes the disadvantages of point sources of illumination, *e.g.* dark shadows and high brightness contrast, providing a more uniform illumination and improved seeing conditions.

(c) Fig. 2 shows a suggested arrangement of lighting equipment for roll floors. Dust-tight fluorescent equipment so installed will deliver the maintained 40 footcandle lighting level recommended for the inspection points on the rolls.

5.3—Packing Areas — Thirty footcandles of general illumination is necessary for this area. The color quality of the light is not important. Supplementary illumination may be necessary for the scale dials and sewing heads.

5.4—Product Control—The illumination requirements here are similar to those for inspection on the roll, sifter, and purifier floors. A lighting level of 40 footcandles of daylight quality is required.

5.5—Miscellaneous Areas

5.5.1—*Critical*

5.5.1.1—There is no luminaire now designed or available which is entirely satisfactory for use in the bins to inspect material level. (See Fig. 6.) The necessary type of lighting unit should be explosion-proof, lightweight, portable, and provide adequate illumination.

5.5.1.2—Floodlighting by the use of permanently located units is recommended around the cleaning screens and man lift areas.

5.5.2—*Non-Critical* — For most noncritical seeing areas such as stairs, aisles, and overhead runways, 10 footcandles of illumination is adequate.

6. Daylight

Past practice in the design of flour mill buildings provides little useful daylight at the seeing tasks. In buildings of such design, therefore, the value of illumination obtained from natural daylight should be considered as supplementary to the artificial lighting requirements. It should not be considered as a part of the lighting system for mill operations and, therefore, should not have any bearing on the artificial lighting design requirements.

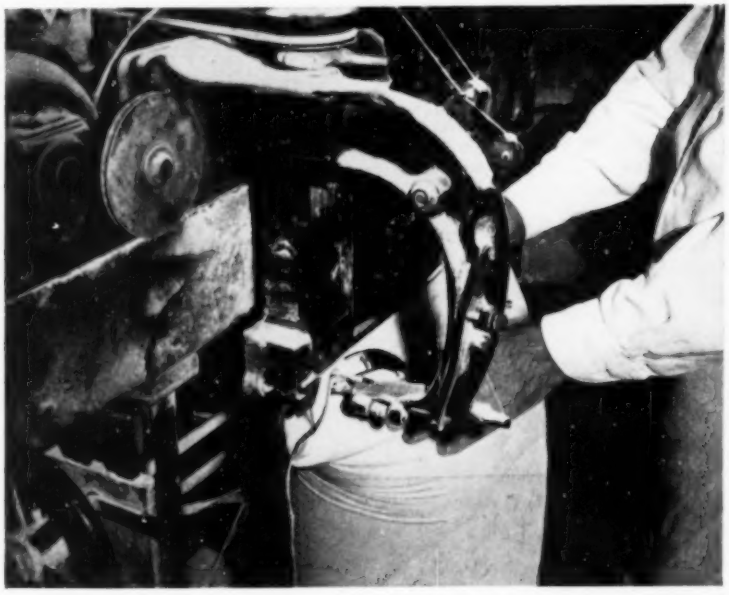


Figure 8. After weighing, the top edges of the filled bag are sewed together.

Acknowledgment is given to International Milling Company of Minneapolis, Minn., for cooperation in furnishing the illustrations used in this report.

TELECAST

LIGHTING NEWS OF CURRENT INTEREST

The French Lick Conference

I.E.S. members who have wondered if a resort hotel is best for the National Technical Conference were convinced in its favor at French Lick, Indiana. Reason: The 1949 Conference September 19-23 was perfectly handled: it featured an outstanding technical program and delightful entertainment; there were abundant facilities for sports and recreation with carefully arranged activities for the women.

Very important, and a most pleasing feature, the some 700 members, wives and guests, spent many hours in cordial fellowship, all under the common roof of the French Lick Springs Hotel, with no other guests present but I.E.S.ers. Away from the hustle of a city, men and women alike participated in the meetings, found relaxation in the beautiful gardens, enjoyed the friendly competition of the golf courses, shuffleboard court, bowling alleys, etc., partook sparingly of the Pluto Water were pleased with the varied entertainment offered. Consensus was that the Executive Committee had fulfilled its promise to produce the "Best Conference Ever." It was even rumored that a deal had been made with the weather man, for nature's all-powerful light source was shining each day with scarcely even a threat of rain.

The Technical Conference

While French Lick offered a superlative setting for fellowship and fun, the aspect of the 1949 Conference of greatest importance to most members was the technical program. Its excellence can be attested by the heavy attendance at all sessions. Of the 486 officially registered delegates (182 ladies made the official total 668) a good majority crowded Convention Hall for all of the technical sessions.

A total of 33 formal papers were presented at eight sessions, with an additional five informal presentations at the parallel session on Residence Lighting Forums on Wednesday morning. For the permanent record, the entire program is listed at the end of this article, and of course, complete text together with discussion will be published in Illuminating Engineering for most Conference papers, starting with this issue.

The opening session is worthy of special mention. Mr. G. J. Oglebay of the Public Service Company of Indiana presented the welcoming address, and Mr. R. F. Hartenstein, (presiding at the request of the President) gave a brief digest of the Conference highlights. This was followed by A. H. Manwaring's Report of the General Secretary.

The President's annual address made particular reference to the need for sharing the huge burden of the office, which now leaves little time for other business or professional activities. Mr. Tayler, text of whose address appeared in the September issue of Illuminating Engineering, also spoke of the Society's financial situation, the registration of illuminating engineers and our professional status. The "Platform Speech" of President-Elect Goddard was a forthright declaration of his intention to "bring the Society to every member" through committee efforts, and local and regional activities. Mr. Goddard's address also was published in September.

A special technical session on Wednesday evening featured the Report of the Committee on Progress, presented by S. G. Hibben, Chairman, and participated in by his entire committee. The Progress Report packed the Hall — with those interested in the many 1949 lighting developments presented —and with those to whom Mr. Hibben's superb presentation is interesting, whatever the theme. To describe only the spectacular and imaginative manner in which the Report was presented would be an injustice to the really valuable data it contained on 1949 developments in many phases of lighting practice.

Another session of special note was the Color Symposium on Thursday afternoon. All of the participants, including Chairman Dean Farnsworth, discussion organizer Norman Macbeth and all three speakers, are prominent members of the Inter-Society Color Council — and in most cases, of the I.E.S. as well. Special arrangements had been made by the Conference Committee for members of the I.S.C.C. and the A.I.D. to attend this session without the formality of registration. A number of distinguished men, from Purdue University, University of Arkansas, University of Cincinnati, and others, attended as guests of the Society. Undoubtedly, however, those receiving the greatest benefit from the color talks were the lighting men themselves, who found a field to which their own work is closely related being presented to them in a new and fascinating manner.

Committee Meetings

A secondary but very valuable aspect of the National Technical Conference is the opportunity it offers for the many technical and standing committees to meet in person for committee discussion. Breakfast, luncheon, dinner and evening periods were filled every day of the conference with numerous meetings. Some of the more notable committee meetings scheduled during the conference included:

Council Executive Committee, September 18, L. E. Tayler, Chairman.

National Technical Conference Committee, September 18, R. F. Hartenstein, Chairman; 15 members.

Lighting of Central Station Properties, September 19, A. A. Brainerd, Chairman; 15 members.

Color and Illumination, September 19, Dean Farnsworth, Chairman; 10 members.

Publications Committee, September 19 and 20, E. C. Huerkamp, Chairman; 10 members.

Light Control and Equipment Design, September 19, F. C. Winkler, Chairman; 8 members.

Street and Highway Lighting Committee, September 19 (all day meeting), Stuart R. Williams, Chairman; 30 members.

Coordinating Committee for National Defense, September 20 (breakfast), A. F. Wakefield, Chairman; 10 members.

Lighting Study Projects in Educational Institutions, September 20 (breakfast), C. N. Laupp, Chairman; 8 members.

Professional Requisites, September 21 (breakfast), R. L. Biesele, Jr., Chairman; 8 members.

Daylighting Committee, September 22, W. C. Randall, Chairman, 10 members. Office Lighting Committee, September 22 (luncheon), G. F. Dean, Chairman.

Local Activities Committee, September 22 (luncheon), Walter Sturrock, Chairman.

Lighting Study Projects in Educational Institutions, September 22 (luncheon), M. C. Putnam, Chairman.

Testing Procedures Committee, September 22 (luncheon), R. P. Teele, Chairman, 20 members.

Medal Award

As one of his last official acts as President of I.E.S., Lee E. Tayler had the honor of presenting to Dr. Ward Harrison, the I.E.S. Gold Medal — highest honor in the field of illumination. (For Dr. Harrison's many meritorious achievements in illuminating engineering, for which he was awarded the Medal, see ILLUMINATING ENGINEERING, May, 1949, p. 304). Dr. Harrison's address of acceptance was of such significance that it is being presented as a featured article elsewhere in this issue.

Prior to the Medal presentation, the history of the I.E.S. Medal Award was reviewed by A. F. Wakefield, Chairman of the 1949 Medal Award Committee. So many comments have been received to the effect that so few of the Society's members are familiar with the Society's highest honor, that Mr. Wakefield's report and history of the Medal, are being quoted herewith:

It is a proper characteristic of a professional Society to reward its members for merit in the profession, as well as for contributions by the membership in the administration of Society Affairs. Our Society has many ways of rewarding its members for either one or both of these considerations, namely:

1. Committee Membership. 2. Authors of Papers and Discussors. 3. Chapter and Section Board Members. 4. Chapter and Section Chairmen. 5. Regional Officers. 6. Directors and National Officers.

However, there are other indices of recognition which are related primarily to merit in the profession:

(a) The Grade of Full Member. (b) The Grade of Fellow. (c) The Honorary Member. (d) Medallist.

When the Gold Medal was first established in 1944, it was intended that the Medal would be the highest recognition for merit in the profession within the scope of the Society. Many members feel that this end has been accomplished in the selection of Medallists to date.

Nominations for the Award can be made by any Member in the United States or Canada, by writing to the General Office requesting consideration of a proposed candidate and accompanying this proposal with a statement of his achievements. At the present time there are three living Medallists in the Society.

The Medal Committee consists of three elder Past Presidents, three recent Past Presidents and three from the membership at large, one from each group being appointed each year, each group serving concurrently.

The Medal ... is 2½ inches in diameter of 10 carat gold and is provided out of the general funds of the Society in those years when a Medallist is designated. You will be interested, at this time, in the interpretation which is provided as a guide to the Committee in its consideration of candidates presented to them by the membership:

1. Furtherance of the Society's object should be a criterion of selection.
2. It should be made clear that the chronological order of awards will not necessarily indicate relative merit of recipients' contributions.
3. It is natural to expect that the award generally will be made to persons of mature age, though the case of a genius might at any time prove to be an exception.
4. The award should honor an individual whose accomplishments in the illuminating engineering field will be rather widely recognized and accepted.
5. Importance of contributions rather than reputation should govern.
6. Service to the public good should be a leading consideration.
7. Accumulated merit should be the basis for appraisal. Contributions may consist in one large achievement or in long sustained, less outstanding contributions. Total accomplishment should be weighed.
8. Weight should be given sustained interest and continuing influence in the illuminating field over a period of time.

Mr. Wakefield mentioned Medallists prior to Dr. Harrison, three of whom are living. Since this honor was established in 1944, the I.E.S. Medal has been awarded to:

1944 George H. Stickney
1945 Preston S. Millar (deceased)
1946 E. C. Crittenden
1947 Dr. Matthew Luckiesh
1948 Sir Clifford Paterson (deceased)
1949 Dr. Ward Harrison

Dr. Harrison's citation read as follows:

The I.E.S. Medal
Awarded to
Ward Harrison

Engineer, teacher, and inventor contributing to the art and technology of lighting to a degree unsurpassed by any member of the profession.

Fellow and eighteenth President of the Illuminating Engineering Society, he was the first to receive the honorary degree of Doctor of Illuminating Engineering awarded him in 1940 by the Case School of Applied Science.

For nearly two decades as Director of Engineering of the Lamp Department of the General Electric Company, stimulating new approaches and initiating new criteria for better and more practical solutions of lighting problems.

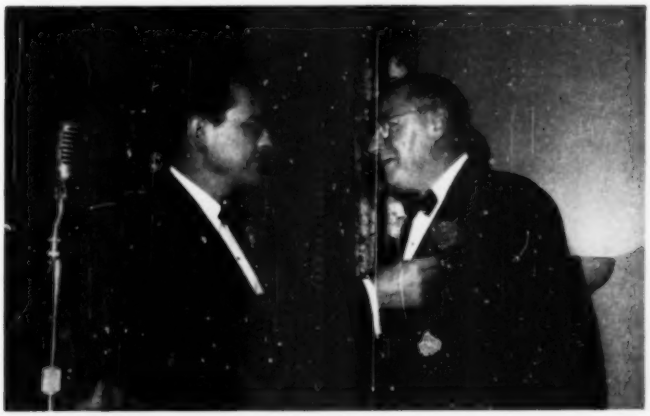
On the occasion of the
Annual Conference
of
The Illuminating
Engineering Society
French Lick,
September 20, 1949

Fellow Pins

As reported in a recent summary of Council action at its June meeting (see ILLUMINATING ENGINEERING, July, 1949, p. 425) distinctive lapel emblems have been authorized for use in connection with the Fellow Grade. The first of these new pins, which are similar in design to those for other grades except that they are in white, were made available just prior to the Conference. Thirteen of them were presented with appropriate ceremony at the opening session of the technical sessions to those of Fellow Grade present at French Lick. Lapel emblems for those Fellows not attending the Con-

ABOVE, part of the head table at the President's Banquet. Shown are Homer Manwaring, Mrs. Taylor, C. H. Goddard, R. W. Butts, L. E. Tayler, Mrs. Goddard, Walter Sturrock and Mrs. Hardacre. In photo at right, the Past-President's Luncheon. Left to right, L. E. Tayler, G. A. Hardacre, S. B. Williams, W. F. Little, Ward Harrison, C. H. Goddard, H. H. Magdsick, W. C. Brown, A. F. Wakefield, R. W. Staud.

- - - - Conference Highlights - - - -



CONFERRING the Past-President's Pin (above). President Goddard's first official act was to present to Lee E. Tayler, the honored Past-President's pin denoting his position in this distinguished body. Other highlights of the Conference included President Goddard's Presidential Address (above right), text of which was published in the September issue; and the always popular Progress Report, presented by S. G. Hibben (lower right). Text of the Progress Report is scheduled for an early issue of **ILLUMINATING ENGINEERING**.

CANADIAN delegation above, came over a thousand miles to attend the Conference. At left, Lee E. Tayler presents the Society's highest honor, the I.E.S. Gold Medal, to Dr. Ward Harrison at the opening session.

BELOW, some of the hardest-working committee members at the Conference. Immediately below is the Ladies Reception Committee who wore distinctive costumes and personally greeted every lady. At the bottom of the page, Bob Smith who seated 700 people at the Banquet without complaints, and Art Weise, who fixed them all with hotel rooms.

ABOVE, two significant awards. Top, the traditional gavel for attendance, plus a beautiful anvil presented by the British Columbia Chapter, is received by W. H. Kahler, Chairman of the winning Cleveland Section. Bottom picture shows some of the 13 Fellows of I.E.S. who were presented with distinctive lapel emblems denoting Fellow Grade.

ference have been sent to their respective Section and Chapter Chairmen for presentation at a local meeting.

Fellow Grade Members who were presented with white Fellow pins at the Conference were:

Arthur A. Brainerd
Willard C. Brown
Oscar P. Cleaver
George G. Cousins
C. L. Crouch
Ward Harrison
S. G. Hibben
L. V. James
W. F. Little
H. H. Magdsick
R. C. Putnam
Walter Sturrock
F. C. Winkler

Other Awards

There are a number of awards now traditional with I.E.S. Conferences, of varying significance but each highly prized. Those carrying the greatest honor are, of course, the Past-President's pin, and the President's gavel, symbol of his office. At an impressive ceremony during the President's Banquet, the gavel, with all its weight of responsibility was presented by Lee E. Tayler to President C. H. Goddard. It was then President Goddard's honor to pin to the lapel of Mr. Tayler, the Past-President's pin, denoting his position among those distinguished members who have served the Society as President.

Another award was presented by Mr. Goddard which though not entirely official carried with it nevertheless, the gratitude and respect of the hundreds of I.E.S. members who have met her. This was a beautiful costume pin presented to Mrs. Lee E. Tayler in recognition of her tireless efforts in the Society's behalf, in accompanying her husband during all of his travels and furthering the well-being of the Society in a most gracious manner.

Though referred to rather familiarly as the "travel gavel," the traditional silver-mounted gavel awarded to the Section or Chapter winning the attendance competition (based on numbers present in relation to Section membership and miles traveled) is highly prized and competed for keenly. The winner was the Cleveland Section, whose Chairman Wm. H. Kahler accepted it for his Section. The gavel this year had the addition of a most beautiful anvil in mahogany and silver, presented by the British Columbia Chapter. That Chapter carried away the gavel last year as winner of the competition. When they found space left on the silver for the addition of only one more Chapter name, on their own initiative they presented the Society with a matching anvil for striking the gavel, on whose silver surface many more names may now be engraved.

Presented at the Banquet also, were the annual prizes to the winning Sections and Chapters in the Membership Competition. First prize of $100.00 went to the Ohio Valley Section, and accepted for the Section by W. J. Wilfert, Chairman. The Montreal Section won Second Prize of $50.00 in the Membership Campaign, and First Prize of $25.00 in the Member Grade Campaign; accepted by J. Thomas, Chairman. Third Prize of $25.00 was accepted by Regional Vice-President T. S. Shepherd for the Northern California Section. Second Prize of $15.00 for Member Grade went to Harold Salaun for the New Orleans Chapter, while Third Prize in this contest, $10.00, was shared by the Cornhusker Chapter and the Georgia Section.

Honorable mention was also made for several top men in the Local Representative Membership activity. Present and introduced were Robert S. Wiseman of Mississippi State College and F. E. Glick, Allentown, Pa. Representatives for Buford H. Martin of Tennessee Valley, and John O. Kraehenbuehl, University of Illinois, also acknowledged the Society's recognition of their outstanding work in their localities.

Two other prizes traditionally up for competition each year are the golf trophies. The G. Bertram Regar silver cup for top Section or Chapter team of four was won by the Cleveland Section with a team made up of M. L. Bettinger, H. E. Carney, J. R. Godfrey and N. H. Vacha. The President Law Trophy for low net handicap was won by Keith E. Nesbitt of Akron, Ohio.

The Lighting Service Forum

The traditional annual presentation of the Lighting Service Committee was held on Monday afternoon, the day preceding the formal opening of the Conference, and was built around the recent E.E.I. nation-wide contest on Planned Lighting. Four winning companies told of local activities and the successful results produced. Harold H. Green of the Lamp Department of General Electric, acted as the Parade Marshall, speaking briefly of the overall program and introducing the individual speakers.

In the first presentation, representatives of New Orleans Public Service Inc., explained their sales training program for commercial planned lighting, how the story was given to the customer and the results to the local lighting industry. "Before and After Industrial P/L Promotion" was the title of the next portion, by the Dayton Power and Light Co., featuring a skit which showed how a hard-boiled industrial executive mellowed under a direct-mail campaign on good lighting. The West Penn Power Company then dramatized their drive for better home lighting, telling of their efforts by lamp shows to stimulate dealer activity in certified lamps. Their presentation included a millinery fashion show, to exemplify the need for portable-lamp shades of the proper size, shape and decorative quality. The last presentation of the Lighting Service Forum was staged by Pennsylvania Power and Light Co. Under the leadership of J. M. Stedman, Chairman of the Lighting Service Committee, the P. P. & L. group portrayed the dilemma of a Pennsylvania-Dutch merchant who heard one story from the contractor, a different one from the utility. Of course, the story ends happily with the education of the contractor.

Personnel responsible for this successful presentation were: for the staging and production, Alston Rodgers, Howard Benz, Will Beck, Bob Dorsey, and Harold Green, all of Nela Park, Cleveland, Ohio.

For the presentation by the New Orleans Public Service Co.: Mason Guillory, Harold Salaun, Jake Gensburger, Conrad Berdon, Harbert Gregory, and Stafford Nothacker.

For the West Penn Power Co., John Mueller and Henry Jones. For Dayton Power & Light Co., C. J. Fuhsman, George Novasie and Harrison Burrell. For Pennsylvania Power & Light, P. H. Hildebrand, H. F. Carroll, Francis Glick, and Howard Kreitzberger.

Taking part also were Myrtle Fahsbender of Westinghouse, Mrs. H. H. Green, Mrs. H. F. Carroll of Allentown, Pa., and Aileen Page, General Electric Co., Nela Park, Cleveland.

HAROLD GREEN, conducting the highly successful Lighting Service Forum, Monday afternoon, September 19.

The Social Calendar

Both the Ladies Reception Committee and the Entertainment Committee went all-out to arrange daytime activities for women and evening pleasure for everyone. Each evening was planned, with varied entertainment to fit every taste — from musical chairs one evening, to the brilliant President's Reception, Banquet and dance on Thursday.

The reception, originally scheduled in the beautiful Oriental Gardens, was held on the hotel mezzanine where sheer evening gowns would not miss the warmth of the sun, scheduled by central standard time to be obscured by the nearby foothills. The receiving line numbered many present and past dignitaries of the Society, at the end of which stood President Tayler and the charming Mrs. Tayler.

The Banquet was held in the Main Dining Room where small tables seating six seemed to make each table a ring of merriment. Pièce de resistance of the prime roast beef dinner was a magnificent dessert, spectacularly served. It had just been observed that the efficient Negro waiters had all mysteriously disappeared, when the dining room doors opened to a parade of the grinning waiters, bearing on their heads (no hands!) huge trays laden with the hotel's celebrated Bombe Mercedes, a most elegant frozen concoction. They paraded the entire room in this manner before serving.

Following the dinner, R. W. Butts, chairman of the Conference Executive Committee, served as Master of Ceremonies. After introducing the head table and giving a brief salute to committee chairmen, Mr. Butts presented the Society's president, who awarded the various trophies and prizes. The names of the recipients have already been included in this resume. Mr. Tayler then passed the gavel of office to President-Elect Goddard, who then officially became the 45th I.E.S. President. His first act was presenting the honored Past-President's pin to Mr. Tayler.

Following the Banquet, the group adjourned to "Club Luminaire" (Convention Hall) for dancing. Later came a show with night-club atmosphere comprising entertainers of national reputation. All too soon, the one o'clock closing hour ended the festivities.

Other evening entertainment included the "Hoosier Jamboree" on Tuesday, with square and "round" dancing, vaudeville acts and a barber-shop quartet contest (won hands down by the Ohio Valley Section). Costumes were colorful and unique, though by far the best was that worn by President Tayler who was all dressed up in the hand-embroidered cowboy shirt and ten-gallon white Stetson presented to him last year by the Southwestern Section.

Monday evening's program consisted of a free Bingo party with approximately 50 very desirable prizes donated by Sustaining Members of the Cleveland and Ohio Valley Sections and the Indiana Chapter. Other "organized play" included a giant-size game of musical chairs in which George Korten (whose contributions to the I.E.S. Street Lighting Committee are usually quite learned) outbumped everybody for first prize. Mrs. Homer Manwaring didn't do so bad either — for second prize.

The Women's Program

Throughout the week, carefully prepared plans for the women guests were carried to smooth completion by a corps of hostesses, each dressed in red-and-white sport blouses and blue skirts for easy identification. Each woman was individually greeted by a member of the Ladies Reception Committee on arrival at the hotel, and information given on various events, to supplement that contained in the special printed program for ladies.

The initial activity was an Autograph Contest which provided additional incentive for the women to meet each other. An intriguing variation was the identification of five "celebrities" based on clues contained in the daily mimeographed "newspaper." The contest was won by Mrs. Frank J. Meder of Cincinnati. On Tuesday afternoon, a Ladies Sports Tournament was featured, with prizes for various events. Winner of the Women's golf championship was Mrs. Frank R. Knowles. On Wednesday morning many of the women took in the Residence Lighting Forum session and in the afternoon drove either to Lanier Home (a southern mansion on the Ohio River noted for its authentic antiques) or to Silver Mill State Park. An option for Wednesday afternoon was a Bingo Party in the hotel.

A LIGHTER moment at the Conference — during the Hoosier Jamboree. Shown are President-Elect C. H. Goddard, Mrs. Tayler, Past-President A. F. Wakefield, Mrs. Goddard, and President Lee E. Tayler, all dressed up in the western outfit presented to him last year by the Southwestern Section.

SQUARE DANCE at the Hoosier Jamboree, typical of a number of other sets who weren't very good at it either. Left to right, Ruby Redford, Charley Amick, Mrs. Amick, R. J. Diefenthaler, Mrs. Diefenthaler, Richard G. Slauer, the hotel's lady tennis pro, and Bob Dorsey.

Thursday's Residence Lighting Technical Session drew many of the women, with the papers concluding in time for a lovely noon luncheon in the hotel dining room. A canasta-bridge party occupied the ladies in the afternoon, and of course, they were in their glory for the President's Reception and Banquet that evening.

"The Newspaper"

One feature of the 1949 Conference which should be all means go into the record, is the unprecedented "daily newspaper" put out every morning of the Conference by an imaginative and hard-working committee. By the second day "Light Chatter," a three-page mimeographed sheet, was so popular that almost no one would go into breakfast before he had obtained a copy. Winnifred Fay as editor-in-chief, and Charley Amick, Larry O'Brien and Ted Wakefield as production staff, did a superlative job on this sheet. It was a most useful and interesting part of the Conference, listing as it did all committee meetings and their locations, daily Conference events, and personal items of real interest. It even included a daily recipe donated by an attending lady, and a "guest editorial" different every day. As committee meetings almost outnumbered technical papers, their daily listing was an invaluable aid.

Acknowledgments

As can be appreciated, many people work very hard to put over a Conference as successful as that at French Lick. In fact, the more effortlessly and smoothly the machinery works, the more surely one can know that much talent and effort went into it. A special vote of thanks is due to Alston Rodgers of General Electric Company, who carried through Al Rees' operation of the mechanical facilities of Convention Hall, upon Mr. Rees' illness. This was an herculean task, performed without a hitch.

The Society's thanks are due to the National Technical Conference Committee for over-all planning of this year's smooth-running Conference. A sincere bow goes also to members of the Conference Executive Committee who worked diligently and long to anticipate and plan for the hundreds of details which arise in a meeting of this magnitude. Of course, the Papers Committee should receive great credit for the fine technical program provided. For many hours of time both before and during the Conference in planning and producing the daily newspaper "Light Chatter," a vote of gratitude goes to Miss Winifred L. Fay, C. L. Amick, L. W. O'Brien and T. D. Wakefield.

On the National Technical Conference Committee: R. F. Hartenstein, Chairman, R. W. Butts, Vice-Chairman, R. R. Brady, W. C. Brown, J. H. Fall, III, Harry Grattan, Jr., Fred Guth, A. D. Hinckley, C. C. Keller, D. W. Prideaux, T. H. Shepherd, R. G. Slauer, J. M. Stedman, H. P. Steele, F. I. Wilson.

On the Papers Committee: H. P. Steele, Chairman, H. L. Wright, Vice-chairman, C. I. Brady, Jr., A. A. Brainerd, W. V. C. Foulks, P. H. Hildebrand, H. H. Horn, K. M. Reid, R. M. Zabel.

On the Lighting Service Committee: J. M. Stedman, Chairman, H. H. Green, Vice-chairman, A. I. Benedict, R. W. Butts, Maxwell Cole, R. R. Enghouser, H. B. Gould, M. A. Havenhill, C. D. Hollister, H. L. Holtman, H. G. Hrivnatz, I. L. Illing, F. E. Mueller, Philip Peeples, G. M. Rankin, W. A. Stannard, C. A. Stevens, H. A. Stroud, C. R. Tracy, L. C. Twichell.

On the Conference Executive Committee: R. W. Butts, Chairman, R. M. Brown, E. B. Bentley, and W. J. Wilfert, Vice-chairman, W. H. Kahler, Secretary, and the chairmen of the following committees.

Attendance and Publicity: C. L. Amick, Chairman, W. L. Fay, E. W. Hodgetts, E. C. Huerkamp, H. D. Leppo, T. R. Lyon, W. C. Mutchler and T. D. Wakefield. The Scrapbook Sub-Committee was composed of T. D. Wakefield, Chairman, W. F. Baldwin, R. R. Enghouser and J. A. Stevens.

Entertainment: R. W. Brown, Chairman, R. W. Wilson, Vice-chairman, E. A. Dailey, J. F. Fuller, R. J. Brueser, T. A. Marshall, C. E. Robison, Jr., Alston Rodgers, R. J. Schulte, L. J. Volk.

Did Someone Find a Golf Club?

A favorite golf club was lost on Thursday, September 22, on the power course at the French Lick Spring Hotel, by H. E. Bracke, while attending the National Technical Conference.

The club lost was a No. 2 Hillerich and Bradsby "Power Built" iron. It was probably put into another bag by mistake. If anyone finds the club in his bag will he please contact H. E. Bracke of the H. E. Bracke Company, 4969 Shirley Place, Cincinnati 5, Ohio.

Transportation: S. F. Davies, Jr., Chairman, J. R. Godfrey, L. F. Heckmann, C. W. Kronmiller, E. F. McGinnis.

Ladies Reception: Mary W. Held, Chairman, Aileen Page, Lucy Bartlett, Harriet West, Co-chairmen, Mrs. R. W. Brown, Mrs. R. M. Brown, Mrs. R. W. Butts, Miss W. L. Fay, Miss S. M. Fetzer, Mrs. W. A. Gale, Mrs. R. F. Hartenstein, Mrs. E. C. Huerkamp, Mrs. W. H. Kahler, Mrs. C. E. Robison, Jr., Miss Mary Taepke, Mrs. A. H. Wiese.

Finance: F. A. Kolb, Chairman, R. J. Breighstein, E. S. Mills, N. G. Smoley, W. F. White.

Lighting and Decoration: H. L. Holtman, Chairman, H. J. Damm, R. T. Dorsey, D. T. Fortner, Cecil Hadley, Kyle Herder, J. M. Lime, W. W. Nentrup, L. B. Staulbh, N. H. Vacha.

Sports: C. W. McFee, Chairman, W. W. Becky, H. C. Blackburn, H. E. Bracke, H. E. Carney, J. C. Darrow, W. A. Gale, Howard Holiday, A. J. Rutterer.

Registration and Reception: A. F. Tucker, Chairman, Ray Anderson, F. L. Detwiler, G. W. Dusendschon, Hilard Francis, M. S. Gilbert, C. A. Jaqua, L. C. Kent, Ned Muse.

Hotel: A. H. Wiese, Chairman, L. C. Kent, Vice-chairman, E. R. Dickinson, H. K. Flint, C. K. Graham, M. D. Pelton, F. S. Reynolds, R. V. Smith.

GENERAL SESSION

Tuesday Morning, September 20

R. F. Hartenstein, *Chairman*

Address of Welcome—G. J. Oglebay, Public Service Co. of Indiana.

Conference Highlights—R. F. Hartenstein, Ohio Edison Co.

Report of the General Secretary—A. H. Manwaring, Philadelphia Elec. Mfg. Co.

President's Address—L. E. Tayler, Detroit Edison Co.

Our Society in 1949-50—C. H. Goddard, Sylvania Electric Products, Inc.

Presentation of I.E.S. Medal to Dr. Ward Harrison—Introduction by A. F. Wakefield, Presentation by President Tayler, Response by Dr. Harrison.

TECHNICAL SESSION

Tuesday Afternoon, September 20

E. H. Raddin, *Chairman*

K. M. Reid, *Discussion Organizer*

Metal Reflector Coatings for Filament Lamps—D. E. Elmendorf and K. M. Reid, General Electric Co.

Thermionic Emission in Gas-filled Incandescent Lamps—R. H. Clapp, Sylvania Electric Products, Inc.

Low Pressure Mercury Discharges—George Meister and T. H. Heine, Westinghouse Electric Corp.

Short Arc Mercury Lamps—G .A. Freeman, Westinghouse Electric Corp.

Humidity Effect on Instant Starting of Fluorescent Lamps—R. C. McFarland and T. C. Sargent, Sylvania Electric Products, Inc.

Color Preference Studies with Fluorescent Lamps—G. B. Buck, II, General Electric Co.

TECHNICAL SESSION

Wednesday Morning, September 21

W. C. Brown, *Chairman*

H. W. Horn, *Discussion Organizer*

Utlization Curves for Floodlights—M. E. Keck, Westinghouse Electric Corp.

Application of Recommended Brightness Limitations in School Class Rooms—F. C. Winkler and J. J. Neidhart, Westinghouse Electric Corp.

The Effects of Luminous Ceiling Elements on Visibility—B. S. Benson, Jr., and E. H. Church, Benjamin Electric Mfg. Co.

Brightnesses in Visual Field at Borderline Between Comfort and Discomfort—Dr. Matthew Luckiesh and S. K. Guth, General Electric Co.

RESIDENCE LIGHTING FORUM

Wednesday Morning, September 21

Priscilla Presbrey, *Chairman*

The Value of the Residence Lighting Forum in the Society—Priscilla Presbrey, Westinghouse Electric Corp.

A Progress Report from the Newest Forum—Ruth Morris, Georgia Power Co.

Appropriate Lighting for Today's Rural Home—Edith L. Buchholtz, Westinghouse Electric Corp.

Television Viewing Habits Revealed by Survey and Recommendations for Better Visual Conditions—Mary E. Dodds, Toledo Edison Co.

Rooms with the New Look—Aileen M. Page, General Electric Co.

PROGRESS REPORT

Wednesday Evening, September 21

Lighting Progress 1948-1949—S. G. Hibben, Westinghouse Electric Corp.

TECHNICAL SESSION

Thursday Morning, September 22

Dr. R. M. Zabel, *Chairman*

Dr. R. M. Zabel, *Discussion Organizer*

Photographs Truly Depicting Lighted Streets—R. M. Hoot, Philadelphia Electric Co. and J. L. Tupper, Eastman Kodak Co.

Lighting Design for Night Driving—Prof. D. M. Finch, University of California.

Low-Mounted Fluorescent Sources for Roadway Lighting—R. G. Slauer, Sylvania Electric Products, Inc.

Roadway Lighting of Shasta and Grand Coulee Dams—R. L. Bossard, U. S. Bureau of Reclamation.

TECHNICAL SESSION

Thursday Morning, September 22

R. R. Brady, *Chairman*

W. V. C. Foulks, *Discussion Organizer*

Laundry Lighting Requirements—A. W. Kakilty, Duquesne Light Co.

Lighting for the Piano in the Home—E. W. Commery and Mary E. Webber, General Electric Co.

Color and Light in the Home—Gladys Miller, Industrial Merchandise & Color Consultant, and Janet Reynolds, Sylvania Electric Products, Inc.

Lighting and Seeing Conditions for Hand Sewing in the Home—Myrtle Fahsbender and Priscilla Presbrey, Westinghouse Electric Corp.

Studies of the Visual and Lighting Problems of Television in the Home—E. W. Commery, General Electric Co.

TECHNICAL SESSION

Thursday Afternoon, September 22

Dean Farnsworth, *Chairman*

Norman Macbeth, *Discussion Organizer*

Psychological Factors of Color in I.E.S. Problems—R. M. Evans, Eastman Kodak Co.

Color Terminology—Dr. D. B. Judd, National Bureau of Standards.

Introduction to Color—Prof. I. A. Balinkin, University of Cincinnati.

TECHNICAL SESSION

Friday Morning, September 23

A. A. Brainerd, *Chairman* and *Discussion Organizer*

Daylight in Classrooms—Prof. R. L. Biesele, Jr., Southern Methodist University.

A New Automatic Recording Distribution Photometer and Simplified Calculation of Light Flux — G. R. Baumgartner, General Electric Co.

Technique of Lighting Generating Stations — H. F. Carroll and W. B. Morton, Pennsylvania Power and Light Co.

One Hundred Footcandles in a Troffer Lighted Classroom — D. E. Mozes, General Electric Supply Corp., and T. R. Anderson, U. S. Bureau of Reclamation.

Modern Photometry of Fluorescent Luminaires — G. A. Horton, Westinghouse Electric Corp.

TECHNICAL SESSION

Friday Afternoon, September 23

A. B. Oday, *Chairman*

C. L. Brady, Jr., *Discussion Organizer*

The Determination of Color Parameters of Fluorescent Lamps — C. W. Jerome, Sylvania Electric Products, Inc.

Special Circuits for Fluorescent Lamps — J. H. Campbell, General Electric Co.

Low Temperature Performance of Krypton-filled Fluorescent Lamps — G. S. Evans, Westinghouse Electric Corp.

The Effect of Operating Cycles on Fluorescent Lamp Performances — F. J. Vorlander and E. H. Raddin, Champion Lamp Works.

Fluorescent Lamp Operation at Low Temperatures — S. McK. Gray, Sylvania Electric Products, Inc.

Performance Comparisons of Hot and Cold Cathode Fluorescent Lamps — F. W. Reuter, Jr., General Electric Co.

Summary of Council Action At Its October Meeting, New York City

Council's first meeting of the 1949-1950 Administration was held at an all-day session on October 13 at Society headquarters, New York City. A summary of the more important action taken follows:

Attending the meeting were: C. H. Goddard, President, presiding; Walter Sturrock and S. G. Hibben, Vice Presidents; A. H. Manwaring, General Secretary; E. M. Strong, Treasurer; L. E. Tayler and R. W. Staud, Past Presidents; Myrtle Fahsbender, Duncan M. Jones, A. F. Wakefield (proxy for R. L. Biesele, Jr.), J. E. Mueller, H. P. Steele and M. N. Waterman, Directors; J. S. Schuchert, G. F. Dean, W. A. Stannard, G. W. Beals, J. B. Browder and S. B. Williams (proxy for T. H. Shepherd) Regional Vice-Presidents; A. D. Hinckley, Executive Secretary. Also present were: R. F. Hartenstein, Chairman, National Technical Conference Committee, E. C. Huerkamp, Chairman, Publications Committee, C. C. Keller, Chairman Finance Committee, George L. Taylor, Chairman Sustaining Committee, R. R. Brady, Board of Managers, New York Section; C. L. Crouch, Technical Director, G. R. Henninger, Publications Director, C. E. Ellis, Advertising Manager, and Ruby Redford, Production Editor.

MEMBERSHIP FIGURES

The Board of Examiners Report was presented by the Executive Secretary for R. C. Kinney, Chairman, submitting for election 15 members and the transfer of 11 Associate Members to Member grade. They also reported to Council their action of electing 85 Associate Members.

Favorable action by Council on the report, together with other membership changes, brings the membership totals, at the beginning of the new fiscal year, to those shown in the following tabulation:

Fellows	44
Members Emeritus	26
Members	1,537
Associates	5,079
Students	228
Total	6,914

NEW FELLOW

The Executive Secretary reported on Council's letter ballot on the recommendation of the Board of Fellows to elect Richard G. Slauer a Fellow of I.E.S. Favorable results of the ballot elected Mr. Slauer the Society's 44th Fellow. Details of his work leading to his nomination are given elsewhere in this issue of Telecast.

FINANCES

A carefully prepared budget for the coming year was presented to Council by C. C. Keller, Chairman of the Finance Committee. The report was approved by Council with a vote of thanks for the tremendous work involved, and it was noted by Council that the Society's budget reflects the increased service of I.E.S. in many aspects of its operation, notably technical work, research, local programs and publications.

COMMITTEE REPORTS

E. C. Huerkamp, Chairman of the Publications Committee presented a report to Council on this operation. By means of large charts showing comparative cost figure for the new publication operation and the old, Mr. Huerkamp disclosed the interesting fact that the new publication in its expanded format and with two additional issues per year, costs the Society less per member than did the old IE. He noted that the cost figure hoped for by the Task Committee which proposed a new publication is now a possibility.

George J. Taylor, Chairman of the Sustaining Membership Committee outlined his committee's approch and organization for this year's activity. He reported that a brochure describing the Society's services and benefits to the industry was nearing completion, to be used by members of his committee in their work.

PROCEDURES AND POLICY

Two reports of the Committee on Procedures and Policies were submitted to Council for G. K. Hardacre, Chairman.

Report No. 12 covered a study of the interpretation of the dissemination of knowledge clause in the Society's Constitution. The Committee's interpretation recommendation approved in principle at the June Council meeting (but returned to Committee for minor revision) was approved.

The Committee found that for the present the following policy statements based upon that adopted by Council in February, 1947 continues to be an adequate guide:

The Illuminating Engineering Society concerns itself with the scientific, technical and aesthetic aspects of illumination. The first consideration in the Society's work shall be that nothing is done which is contrary to the public

interest. Its primary responsibility in disseminating information, in education and in other services is to its members. Beyond this the Society should strive to make its findings available by suitable means, especially through other scientific, professional and technical organizations and the various electrical and other industry groups concerned with lighting.

Report No. 1 of the Procedures and Policy Committee, covering the preparation of illumination performance recommendations for luminaires was referred back to the Committee for clarification after Council discussion.

Technical Conferences In 1952 and 1953

After reviewing financial statements etc. of the 1949 French Lick Technical Conference, R. F. Hartenstein, Chairman of the Conference Committee, reported recommendations reached by his committee with regard to the 1952 and 1953 Conferences. He reported that one formal invitation had been received from the Sections and Chapters for the 1952 Conference, this from the Chicago Section. His Committee had also received an invitation from the New York Section to hold the 1953 Conference in New York City. Noting that hotel and other commitments must be made at least two years and sometimes three years in advance, Mr. Hartenstein requested tentative approval to establish dates in Chicago for the 1952 Conference and in New York for the 1953 meeting. Council gave tentative approval subject to letter ballot, and requested that a report of this action be sent to all absent Regional Vice-Presidents, noting that Technical Conferences are established three years in advance of their date.

Two New Sections

In his report on Local Activities, S. G. Hibben, Chairman, called on J. B. Browder, Southern Regional Vice-President, to report on the progress of the new Chapters in his Region, no less than three of which have been formed in a single year. Mr. Hibben remarked that every time Mr. Browder appeared at Council he presented a petition for a new Chapter—Mr. Browder countered by presenting a petition for a new Section—from New Orleans Chapter, now petitioning for Section stated. It was so voted.

A petition was also presented by Mr. Hibben for Section status for the South Texas Chapter. Council also approved this petition.

Other Council action on Local Activities included approval to change the boundaries of the Quebec Chapter to include the territory between Quebec and the Martitimes Chapter; and to approve in principle the formation of two new Regions, the details and boundaries of which are to be worked out later.

I.E.S. Research Fund

As Chairman of the Board of Trustees of the I.E.S. Research Fund, A. F. Wakefield reported on the status to date of the Research Fund. He reported that Ward Harrison, Chairman of the Research Executive Committee, which held a meeting in French Lick in September, is preparing a Progress Report on all of the researches to date, some of which have been completed. Noting that while there are now (a) more projects needing research, (b) more facilities available and (c) more graduate students to conduct the studies, there are now almost no funds available in the Fund. He recommended that a committee be appointed to explore this situation, and Council approved the appointment of L. E. Taylor as Chairman, and W. H. Robinson, Jr., R. W. Staud, A. H. Manwaring and S. B. Williams. Council also approved the nominations from which the Board of Trustees will fill the vacancies on the Board and on the Research Executive Committee. Approved were:

Trustee: (one to replace A. W. Deller, whose term expires)
- Anthony W. Deller
- Horace P. Liversidge
- George E. Whitwell
- Henry P. J. Steinmetz
- Ralph Wagner

Research Executive Committee: (two, to replace W. E. Folsom and G. R. Harrison whose term expire)
- George R. Harrison
- Glenn A. Fry
- R. M. Zabel
- Williard Allphin
- W. E. Folsom

Technical Report

C. L. Crouch, the Society's Technical Director, presented to Council progress reports for the Society's technical committees, noting especially a two-day Conference to be held in Indianapolis by the Aviation Lighting Committee with a number of foreign delegates expected to attend. He reported also that the Daylighting Committee has received evidence of considerable interest on the part of architects in their forthcoming Recommended Practice of Daylighting; that the Industrial Lighting Committee is now working on the final draft of their report which is planned to be submitted to A.S.A. Mr. Crouch further reported on the progress being made by the Committees on Light Control and Equipment Design, Street and Highway Lighting, Bakeries, Laundries, Canneries and others.

Richard G. Slauer Elected Fellow, I.E.S.

On the recommendation of the Board of Fellows, Council at its October 13 meeting, elected Richard G. Slauer to the grade of Fellow of I.E.S.

At present Manager of the Applications Laboratory of Sylvania Electric Products Inc., Salem, Mass., Mr. Slauer began his career in illuminating engineering in 1926 with the General Electric Co.'s Edison Lamp Works, Harrison, N. J. Under the late A. L. Powell, Mr. Slauer was closely identified with the Edison Lighting Institute, a natural stepping stone to his appointment as Technical Director of the Westinghouse Lighting Institute, which company he joined in 1930.

Mr. Slauer's work has been divided into two classes—educational and application. In his educational work in lighting, one of his most notable achievements has been the complete development, writing and managing of a correspondence course on illumination for which over 6,000 students registered. In addition to writing the course, offered by Westinghouse in 12 assignments, all correspondence with students, the correction of examination papers and special organization of graduation programs, were handled personally by Mr. Slauer. Still treasured are envelopes bearing postmarks in Siam, India and other foreign countries.

In his application work Mr. Slauer has covered almost every variety of lighting application. Some of the more prominent installations with which he has been connected include special studies for spectacular lighting at the Chicago and New York World's Fairs. He has been in close cooperation with the industry on color through the In-

R. G. SLAUER

ter-Society Color Council (serving as the Illuminating Engineering Society's representative for three years) and is noted also for his basic work on the application of sodium lamps, inspection lighting researches, and his active participation in adequate wiring development. In regard to this latter work, Mr. Slauer, as Secretary of the Industry Committee on Interior Wiring Design (representing I.E.S.) wrote the complete first edition and edited later editions of the committee's *Handbook of Interior Wiring Design*, still in use in the industry.

Outstanding in Mr. Slauer's career has been his service to the Illuminating Engineering Society. With I.E.S. his record has emphasized technical rather than administrative committees, although one of his more important assignments—the Publications Committee, of which he was Chairman for three years, may be considered both. Parallel with this, he prepared the manuscript which led to 90 pages of the *I.E.S. Lighting Handbook* and as an active member of the Handbook Committee, he read and criticized much of the remainder. Perhaps his most important administrative assignment was the Chairmanship of the Boston National Technical Conference in 1948.

Mr. Slauer has served in numerous I.E.S. committees, as chairman or member, and is currently active on six national committees; Publications Committee, Coordinating Committee for Defense, National Technical Conference, Lighting Study Projects in Industry, Progress, and Street and Highway Lighting.

He has contributed a number of valuable papers to the *Transactions* of I.E.S., his most recent being presented before the National Technical Conference last September in French Lick, Indiana.

School's Opened

But it isn't the same old grind—not in the lighting field. There's nothing stereotype about the illumination courses offered in Chicago, Montreal, Pittsburgh and New York, among others. In each locale, the material has been slanted to the expressed needs and interests of those both new and old to the subject.

Most of these courses also reflect the growing trend for local university sponsorship of I.E.S. courses. This practice is almost in the majority this year.

In Montreal, McGill University is presenting an Illumination Design course of 15 lectures, as part of their regular Extension Department curricula, in cooperation with the I.E.S. Montreal Section. The subjects covered were planned for the university by the Section, all of the lecturers are Montreal Section members, and the I.E.S. Lighting Handbook is the chief reference source.

Similarly, the Fundamentals of Illumination course sponsored by the New York Section, has for the second year been taken over by New York University to extend from Oct. 3 to Jan. 23. The course outline was planned by the Section's Educational Committee and the faculty is made up of Society members.

Another illumination course underway in New York is that being conducted by the Illumination Division of the New York A.I.E.E. Their Advanced Seminar on Lighting Design covers eight round table discussions under the direction of leading architects and engineers, from October 25 to December 13. The program consists of discussions on vision, lighting design and application and offers an opportunity for an exchange of ideas with outstanding specialists.

The Chicago courses have, of course, been jointly sponsored for a number of years by I.E.S., Chicago Lighting Institute and the Illinois Institute of Technology. Their Course No. I, Lighting Fundamentals (one of five planned to run more or less concurrently) is presented weekly from October 3 to December 19. Course No. II, Lighting Design Problems is planned for the winter quarter; Course No. III, Specialized Lighting Design, for the spring quarter; Course No. IV, Light and Color, is underway now, from October 19 to December 7, as is Course No. V, Wiring Design, October 4 to December 20. The Chicago courses feature laboratory work at Illinois Institute and the Chicago Lighting Institute.

In Pittsburgh the Electric League of Western Pennsylvania has joined with the Pittsburgh Section of I.E.S. in sponsoring a fundamentals course which they found last year was popular with contractors, jobbers, distributors, and utility men. To meet the problems of those already in the field, an intensive eight session course is offered with emphasis on application. Listed according to sessions, the subjects covered are:

1. Light Is What You Make It; Light Vision; Illumination Terminology.
2. Quantity Requirements of Good Illumination; Importance of Color in Illumination.
3. Incandescent, Electric Discharge and Fluorescent Lamps.
4. Principles of Light Control; Systems of Light Control, Calculation of Interior Illumination.
5. Office and School Lighting.
6. Store Lighting.
7. Store Lighting.
8. Industrial and Floor Lighting.

Quick but thorough training will be provided through the use of sound slide films and the class will be conducted by experienced, well-qualified engineers.

Thirty-Six New Home Lighting Ideas Demonstrated

Thirty-six ways of using light in the home are being demonstrated in the new group of rooms opened recently at the Sylvania Lighting Center, 500 Fifth Ave., N. Y., where the theme this year is the renovation of the second floor of a 30-year old house.

Based on the before and after theme of the 1948 Sylvania Lighting Center, which illustrated how the main floor of a dingy 30-year old house can be brought up-to-date, the new rooms show how modernization with light, color and a few architectural changes can transform the second floor into

flexible and colorful living quarters. Possible solutions to lighting problems which exist in every home are demonstrated. The rooms suggest lighting and furnishings for a master bedroom and adjoining television-sitting room, a studio type bedroom where two boys can display their toys and keep them in place easily, a den for a man's hobby collection, a small gymnasium converted from an obsolete upstairs porch, and a completely modernized bathroom which can be used by more than one person at a time and still allow a feeling of privacy for each.

In addition, three enclosed alcoves show how a kitchenette or snack bar, a launderette and a boy's stamp collection corner can be conveniently fitted into the second floor hallway to make a complete apartment out of the upstairs area of an old or a new house.

The Center is open daily for public inspection.

LIGHTING CALENDAR

Society Events

December 8, 1949 — Meeting of I.E.S. National Council, New York, N. Y.

February 8, 1950 — Meeting of I.E.S. National Council, New York, N. Y.

February 16-18, 1950 — Southern Regional Conference, Atlanta, Ga.

February 26-28, 1950 — Southwestern Regional Conference, Dallas, Texas.

April 6, 1950 — Meeting of I.E.S. Council, Edgewater Beach Hotel, Chicago, Ill.

May 8-9, 1950 — Great Lakes Regional Conference, Buffalo, N. Y.

May 11-12, 1950 — Canadian Regional Conference, Montreal, Que., Canada.

June 7, 1950 — Meeting of I.E.S. National Council, New York, N. Y.

August 21-25, 1950 — Southern California National Technical Conference, Pasadena, Calif.

Industry Events

November 8-11, 1949 — National Electrical Contractors Association, 1949 Annual Convention, Rice Hotel, Houston, Texas.

November 10, 1949—Eastern Electrical Wholesalers Association, Membership Meeting, Governor Clinton Hotel, New York City.

November 14-18, 1949 — National Electrical Manufacturers Association, Chalfonte-Haddon Hall, Atlantic City, N. J.

December 4-7, 1950 — The American Society of Refrigerating Engineers, 45th Annual Meeting, Edgewater Beach Hotel, Chicago, Ill.

December 26-31, 1949 — The American Association for the Advancement of Science, 116th Meeting, Statler Hotel, New York, N. Y.

January 14, 1950 — Independent Electrical Contractors Association, Inc., Annual Dinner and Dance, Hotel Astor, New York, N. Y.

January 23-27, 1950—American Society of Heating and Ventilating Engineers, Annual Meeting, Dallas, Texas.

January 23-27, 1950 — New York Lamp Show, Hotel New Yorker, New York, N. Y.

January 30 - February 3, 1950 — American Institute of Electrical Engineers, Winter General Meeting, New York, N. Y.

February 6, 13, 20, 27, March 6, 13, 20, 27, 1950 — Essex Electrical League, 5th Annual Light and Power Conference, Public Service Building, Newark, N. J.

February 27 - March 3, 1950—American Society for Testing Materials, Committee Week and Spring Meeting, Hotel William Penn, Pittsburgh, Pa.

March 7-10, 1950 — Essex Electrical League, 6th Annual Electrical Industrial Exposition, Newark, N. J.

March 13-16, 1950—National Electrical Manufacturers Association, Edgewater Beach Hotel, Chicago, Ill.

March 28-31, 1950 — Greater New York Safety Council, 20th Annual Safety Convention and Exposition, Hotels Statler and Governor Clinton, New York, N. Y.

April 4-6, 1950 — Edison Electrical Institute, 16th Annual Sales Conference, Edgewater Beach Hotel, Chicago, Ill.

June 6-8, 1950 — Edison Electrical Institute, 18th Annual Convention, Atlantic City, N. J.

June 12-16, 1950 — American Institute of Electric Engineers, Summer General Meeting, Pasadena, Calif.

June 12-16, 1950—National Association of Electrical Distributors, Atlantic City, N. J.

Lighting Meetings Planned For Electrical Contractors

A lighting activity of particular merit is at present underway in Lowell, Mass. Three meetings geared to the special interests of contractors and electricians are being sponsored by the Lowell Electric Light Corp., with a four-weeks' lighting course planned for the winter.

The three meetings are being sponsored by the lighting company for the purpose of creating a greater interest in lighting on the part of master and journeymen electricians in daily contact with the public. Lighting education of, and class cooperation with electrical contractors has long been a desirable aim, and Frank H. Jones, I.E.S. Local Representative in Lowell, reports this activity with considerable satisfaction.

Speakers at the first meeting on October 6 were J. L. Steffenhagen of the Westinghouse Electric Corp., Boston, who discussed the fundamentals of good lighting layouts; and John M. Muse, also from Westinghouse who presented a device demonstrating the importance of adequate wiring and circuit protection.

A group of about 65 electrical workers attended the first meeting at the Light Corporation's Assembly Hall. Their interest in lighting was evidenced by 39 signatures for the proposed four-weeks' lighting course to be held in Lowell.

Queber Chapter Holds Charter Celebration

I.E.S. history was made at Quebec City recently when the Society's first bi-lingual group officially became a Chapter at a special "Charter Night" dinner dance held September 12 at the St. Louis Hotel. Some 46 proud members and their wives saw Chairman George Watters receive the new Chapter's Charter from Duncan Jones, Regional Vice-President.

The new Chapter was also presented with an historical gavel as a gift from the Southeast Florida Chapter. Made of lignum vitae (the wood of life), the gavel was presented by J. Thomas, Montreal Section Chairman representing A. C. Bergh, Chairman of the newly formed Chapter in Miami.

Telegrams and letters of congratulations (including one written in French from President-Elect Goddard) were read from the Society's officers and

QUEBEC CHAPTER Charter Night, September 12, Hotel St. Louis, Quebec City. In photo at left, Chairman George Watters receives Charter from Duncan Jones, Canadian Regional Vice-President. Left to right are R. C. Thomas, Gilles Sarault, H. Russell Payson, Joe Thomas, Mrs. George Watters and John H. Ward. In photo at right, Joe Thomas, Montreal Chairman, presents new Chapter with historic gavel from Florida Chapter.

many well-wishers in the Quebec area lighting industry.

With the ceremonies ending at 9:30, the new Chapter celebrated its inauguration with a dance to 1:30 a.m.

Cigar Color Not Affected by Light

The only "light" which materially affects the appearance of cigars is that which is applied to one end as the smoker puffs at the other.

This was revealed by exhaustive tests conducted in General Electric's Research Laboratory to determine whether artificial lighting in show cases would cause objectionable fading of cigars. The studies were made at the request of the cigar Institute of America.

A. H. Taylor, physicist, who supervised the investigations, said results indicated that a minimum exposure of 40,000 footeandle-hours is required to give a barely perceptible color change. This would amount to almost five weeks of exposure, 12 hours per day and seven days per week, at 100 footcandles, maximum light intensity measured in cigar display cases of Cleveland stores.

"If the retailer will place his fastest moving cigars in the brighest illuminated position in the case, and the slower moving ones near the back and ends of the case, fading should not be a problem," Mr. Taylor said.

The G-E tests employed a cigar display which contained a 64-inch-long, three-quarter-inch diameter white fluorescent lamp. Light intensities varied from 77 footcandles under the lamp to 10 footcandles in the rear corners of the case. Seven brands of cigars were used, exposures covering a period of three months. Maximum exposures totaled approximately 150,000 footcandle-hours.

It was found that at 80,000 footcandle-hours, although color change was noticeable it was not objectionable, according to Taylor. This was true even when exposure was increased to four times that for minimum perceptible color difference, he said, explaining that in the case of an actual cigar display there would not be a "control," or unexposed cigar, adjacent to the exposed one, and that as a result, fading would be very difficult to detect.

"The natural color differences of the wrapper leaves in a single box tend to diminish any faded appearance caused by artificial light," according to Taylor. "The entire problem is lost with many cigar smokers who prefer a lighter leaf," he said.

A.I.D. Announces Design Competition

Entry forms are now available for the recently-announced design competition initiated by the American Institute of Decorators to award citations of merit to the designers of outstanding work in lighting, furniture, fabrics, floor coverings and wall coverings. The object of these citations is to make known to the consumer public what the market offers in good design, and to commend the designers who in the opinion of the jurors have created the best designs in these fields.

The A.I.D. is urging all designers in these fields who have designed products offered for sale not prior to January 1st, 1949, to compete in the contest, including qualifying students. Submission of designs must reach the A.I.D. by January 10, 1950.

Entry forms for the competition are available from the national headquarters of the American Institute of Decorators, 41 East 57th Street, New York 22, N. Y.

Southeast Florida Chapter Holds International Meeting

The newly-formed Southeast Florida Chapter started off its first year with a meeting in Miami of Conference proportions, September 30, with 132 people from adjacent states and Cuba attending a gala "International Night." Highlights of the meeting, which was sponsored jointly by the Southeast Florida and the Florida Chapters, was the re-presentation by the Regional Vice-President, J. B. Browder, of the new Chapter's official Charter, and the presentation from the Maritime Chapter, St. John's, New Brunswick, of an historic gavel. With the gift of a similar gavel sent to the new Quebec Chapter by the Southeast Florida group, the international cooperation was doubly symbolized in the persentation ceremonies.

Guest speakers at the meeting included S. G. Hibben, Vice-President of I.E.S., who addressed the group on "This Golden Half Century of Lighting Progress"; R. B. Roberts, Jr., Director of Economic Research, Florida Power & Light Co., and McGregor Smith, President of that company, who welcomed the new group in activities in the Florida lighting industry.

J. B. Browder, Southern Regional Vice-President, formally presented the Charter (which had been informally presented last July 7) to A. C. Bergh, Chairman of the new group, together

SOUTHEAST FLORIDA Chapter International Night, September 30 at the Columbus Hotel, Miami, included many notable figures in the lighting field. Left to right, H. W. Fanus, Vice-Chairman Florida Chapter; J. H. Akerman, Sec., Southeast Florida Chapter; Mrs. Fanus; A. C. Bergh, Chairman, Southeast Florida Chapter; W. B. Shenk; R. B. Roberts, Jr., Florida Power & Light Co.; N. H. Bollinger, Vice-Chairman Southeast Florida; S. G. Hibben, Vice-President, I.E.S.; McGregor Smith, President, Florida Power & Light Co.; J. B. Browder, Regional V-P; Mrs. Bergh; J. A. Banton, Chairman, Florida Chapter; Jess Thomas, Chairman-Elect; Mrs. Akerman; W. P. Covington, Secretary, Florida Chapter.

with the Maritime gavel, and installed the 1949-50 officers and managers of the Florida Chapter and Southeast Florida Chapter.

IT SEEMS TO ME

Lighting by Prescription

To the Editor:

In the July, 1949, ILLUMINATING ENGINEERING, Mr. L. C. Butler has written on "Lighting by Prescription." I am in sympathy with his aims of providing higher levels of better quality illumination, but it seems to me that some of the statements in his paper may furnish further ammunition to those outside the lighting profession who like to criticize us. We have enough valid reasons for recommending reasonably high levels so that we need not make unsupported claims.

For example, the author says ". . . it is axiomatic that when the illumination is inadequate for the seeing task or the contrast low, the muscles that control the eye are impelled to vainly 'hunt' in accommodating the eye to a focus that will produce as clear an image as possible on the retina and this over-activity causes muscular fatigue . . ."

Such a statement is far from "axiomatic"; in fact it is much more specific than any physiological, ophthalmological or psychological knowledge today permits. Even the actual nature of fatigue is as yet unknown, according to distinguished participants in the symposium described in Bartley's recent book.[1]

Statistics which purport to show varying percentages of ocular defects with different occupations have had rather wide circulation in lighting publications, but they are actually open to considerable doubt.[2] It is just as likely, for example, that a farmer's superior vision is due to the healthy life he lives rather than a result of his doing less visual work.

The author says, "Research reveals that 28 per cent less energy is expended in the process of seeing when the illumination is increased from limi nal seeing needs to adequate lighting for the seeing tasks." This statement is obviously in error, since there is as yet no known way of measuring the energy expended in seeing. If there were, many of the researches currently sponsored by the I.E.S. Research Fund and by the S.Q.Q. Committee would be unnecessary.

Without giving the specific reference, Dr. George Wald of Harvard University is quoted as saying, "During the war it was often found that men whose vision was of equal strength in normal bright light differed as much as ten times in their ability to see in weak unfavorable light."

I wrote to Dr. Wald for further information on this and have just received a reply upon his return from Europe. This accounts for my delay in commenting on the original paper. Dr. Wald informs me that what he meant by "weak unfavorable light" was that involving scotopic vision. Since this is in the order of 0.01 footcandle or less, it hardly seems important in the prescription of indoor lighting.

Possibly if the controversial statements and quotations had been documented with references, the effect would have been somewhat different, but I suggest that when dealing with anything as complex as human vision, we as lighting people, should not allow our enthusiasms to run ahead of proven results in psycho-physiological research.

WILLARD ALLPHIN
Sylvania Electric Products Inc.
Salem, Mass.

I.E.S. Transactions for Sale

To the Editor:

I have recently moved into a new home and am now engaged in unpacking many trunks and boxes of books, sorting and classifying them and putting them into my library.

So far, I have uncovered *I.E.S. Transactions* complete in all respects for the years 1936 to date, inclusive. I think my membership goes back a little farther, but whatever it is, I have

the file complete since the date of my joining the Society.

Unfortunately, I have not the shelf space available to hold this worthy and important lot of books, so it is for sale or disposition to worthy institutions, which would make the correct use of it. it.

Wm. P. Baer
8344 Lullaby Lane,
Van Nuys, California

Industry Toasts Trumbull B/L-B/S Program

In testimonial to a man, and to the strength of an idea put across by that man, a group of 158 persons gathered for dinner Thursday, October 13, in the East Ballroom of the Commodore Hotel in New York City. The occasion was the retirement of Glen R. Trumbull after 15 years as Director of the Better Light—Better Sight Bureau to "become President of the Florida Front Porch Rocking Chair Association." Incidentally, the occasion turned also as a celebration in recognition of the 15th Anniversary of the B/L-B/S program, which was originated in 1934 by a group of far-seeing leaders of the industry and which has been continuously under the guiding leadership of Glen Trumbull.

The dinner group was widely representative of both the electrical manufacturing and electric utility industries. Toastmaster for the occasion was Ralph P. Wagner of the New York Power & Light Corporation, Albany, N. Y. The two feature speakers were Merrill E. Skinner of the Union Gas and Electric Company, St. Louis, and George E. Whitwell of the Philadelphia Electric Company.

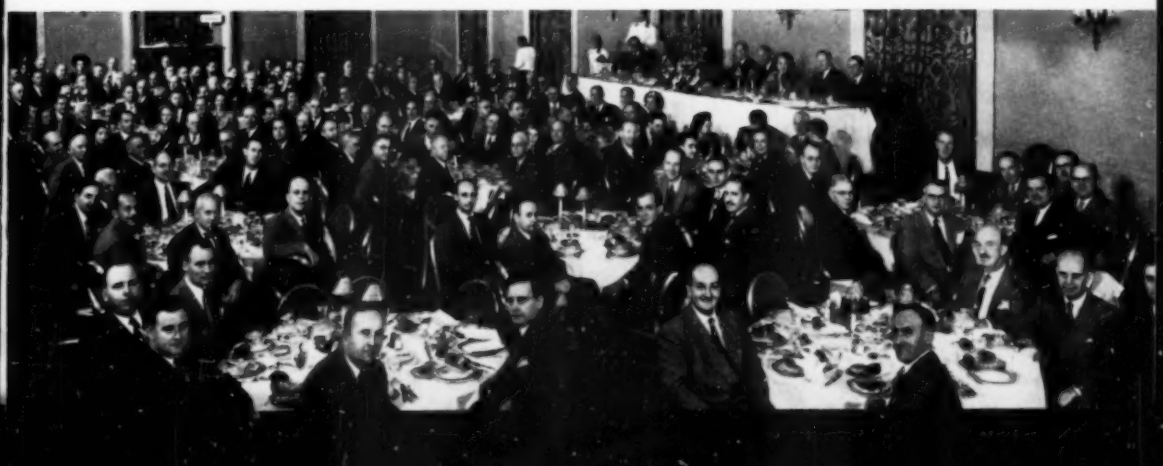
Mr. Skinner emphasized the fact that "the Better Light—Better Sight Bureau is the longest lived member of a large family of special educational agencies of the electrical industry." He gave much of the credit for this "to Glen Trumbull for his tireless, patient and constructive work to vitalize the slogan 'Better Light—Better Sight'." Recounting the Bureau's work not only in the residential and commercial fields, but also in support of public contributions in helping to meet wartime requirements of lighting for a high level of wartime production on one hand, and blackout requirements on the other, Mr. Skinner characterized the B/L B/S program as being the "most important element of effective social service in which the electrical industry has participated to date."

Mr. Whitwell characterized the B/L-B/S program as the "first completely cooperative endeavor to be undertaken by normally competitive elements in the public interest for common good." Drawing a parallel, Mr. Whitwell considered briefly the present and the future prospects of the electrical industry in the light of local and national politics. He urged cooperative industry efforts and public education on a wide scale. Said Mr. Whitwell: "The utility industry is a tremendous paradox. It now enjoys better public good will than ever before, and yet its political status is at a low ebb never before reached." Mr. Whitwell urged "that not only the utilities but other elements of the electrical industry including the lamp manufacturers should get together and really get into this matter of public education in the public interest, to offset and obviate continuing political encroachments and do this before elections, not after."

In acknowledging the gift of his friends and the sentiments of the occasion, Mr. Trumbull paid tribute to the high quality of lighting engineering work that has been done and still is being done. He strongly emphasized, however, the need for "an enormous increase in the manpower actually engaged in selling far and wide the philosophy of lighting."

H. P. J. Steinmetz, of the Public Service Electric and Gas Co., Newark, N. J. was the Chairman of the General Committee responsible for the testimonial dinner. Working with him on this Committee were I.E.S. President Charles H. Goddard and R. H. Bishop of Sylvania Electric Products, Inc.; Past-Presidents L. E. Tayler of the Detroit Edison Company and R. W. Staud of the Benjamin Electric Manufacturing Co., Des Plaines, Ill.; J. P. Contsworth of the Edison Electric Institute, New York; F. R. Innes of *Electrical World*, New York; Don Julien of Certified Lamp Makers, Cleveland, Ohio; James Krieger of Krieger Publications, Inc., New York; H. E. Plishker of Westinghouse Electric Corp., Bloomfield, N. J.; Harry Restofski of West Penn Power Company, Pittsburgh, Pa.; W. H. Robinson, Jr., General Electric Company, Cleveland, Ohio; J. S. Schuchert of Duquesne Light Company, Pittsburgh, Pa.; J. M. Stedman of Pennsylvania Power and Light Co., Allentown, Pa.; C. A. Stevens of Public Service Electric and Gas Co., Newark, N. J.; and Ralph P. Wagner of New York Power and Light Corp., Albany, N. Y.

BETTER LIGHT-BETTER SIGHT—15th Anniversary Dinner and tribute to Glen R. Trumbull, retiring Managing Director, Hotel Commodore, October 13, 1949. At speaker's table, left to right, Charles A. Eastman, Ebasco Services, Inc., Harry Restofski, Chairman, Commercial Vice-President, Philadelphia Electric Co.; Glen R. Trumbull; Ralph P. Wagner, Chairman of the Bureau; Mrs. Trumbull; Merrill E. Skinner, Vice-President, Union Electric Company of Missouri, and Charles H. Goddard, President, Illuminating Engineering Society.



ABOUT PEOPLE

Dr. I. A. Balinkin, Professor at the University of Cincinnati, Cincinnati, Ohio has been elected chairman of the Inter-Society Color Council for the term 1950-51. Elected to serve with him were **A. H. Croup**, Vice-Chairman, **Dorothy Nickerson**, Secretary, **Norman Macbeth**, Treasurer, and **I. H. Godlove**, **C. R. Conquergood**, **Harry Helson**, **D. L. MacAdam** and **E. I. Stearns** as Counselors.

The appointment of **H. J. Hanbury** to the newly-created position of sales manager of Westinghouse photographic lamps and Christmas tree bulbs was announced recently from the Westinghouse Lamp Division, Bloomfield, N. J. Mr. Hanbury, who joined Westinghouse as a New Jersey lamp sales representative in 1931, has held managerial positions since 1938.

Willett R. Wilson has been appointed advisory engineer handling photographic lamps at the Westinghouse Lamp Division, Bloomfield. Mr. Wilson, who joined Westingingshouse in Bloomfield five years ago, left a position as chief of the lighting division, Consolidated Edison Co. of New York City, to become regional lighting control officer for the U.S. Office of Civilian Defense during the war.

Stuart Goodwillie has been named Manager of the Business Relations Department of Sylvania Electric Products, Inc. and will also service national lighting accounts. Until recently manager of Central Station Sales for Sylvania Electric, Mr. Goodwillie has been with the company since 1942 and is a veteran in the sales management field.

Appointments to General Electric Lamp Department Sales district managerships were announced recently by Fred F. Haroff, general manager of the department. **John R. Colville, Jr.** of Milford, Conn., who has been a salesman in the New York Sales District, has been promoted to the position of manager of the Indiana Sales District; **Joseph M. Lime**, of Indianapolis, Ind., has been transferred to the Midwest Sales District from the Indiana Sales District.

Benjamin S. Benson Jr., of the Ben-Jamin Electric Manufacturing Co. has been promoted to Chief Engineer of that company, succeeding **John H. Waterbury**. Mr. Waterbury, who has reached retirement age, will continue as consultant on illumination for the company.

Glen R. Trumbull, for the past 15 years Manager of the Better Light Better Sight Bureau, has announced his retirement. Mr. Trumbull plans to become "President of the Florida Front Porch Rocking Chair Association." Details of the testimonial dinner held by leading men of the lighting industry in his honor are given elsewhere in this issue.

Mildren E. Hatry has been appointed a lighting consultant to National Broadcasting Co. Mrs. Hatry, who is also lighting consultant to Radio Corp. of America, will work with the NBC television program department on the improvement of television lighting to achieve greater realism and the elimination of distortion.

Juan Martinez Vela, Inc. of San Juan, Puerto Rico, has been named Puerto Rican distributor for Colonial Electric Products Company of East Paterson, New Jersey according to Charles L. Sabatini, president.

Van Rensselaer Lansingh, a Charter Member of I.E.S. and the Society's seventh President was presented with a certificate denoting Member Emeritus grade at the meeting of the New York Section, October 11. Mr. Lansingh was elected to Member Emeritus at a recent meeting of the Board of Examiners, in recognition of his years of service to the Society. Mr. Lansingh was a valuable contributor to the early *Transactions* of I.E.S. and served in numerous committee and executive positions, as well as President of I.E.S. (1912-1913).

William C. Norvell, manager of Aviation Lighting Sales for Westinghouse Electric Corp. resigned last month to begin a three-year course in the Virginia Episcopalian Theological Seminary, as a candidate from the Diocese of Michigan. Mr. Norvell also resigned from the Aviation Lighting Committee of I.E.S.

The late Lorin C. Brown

Obituary

Lorin C. Brown, 1947-1948 Chairman of the New York Section, died October 10 in Mercy Hospital, Pittsburgh, after an illness of 18 months. His age was 41.

Mr. Brown was in charge of commercial and industrial lighting application for the Westinghouse Lamp Division, Bloomfield, New Jersey, and was a most valuable and active member of I.E.S. Chairman of the Store Lighting Committee during 1947-1948, he had served previously on several other national I.E.S. Technical groups, notably the Office Lighting Committee, the Committee on Public Buildings and Private Institutions, Committee on Technical Forums, and others in many cases as Chairman. In New York Section activities, in addition to his office as Chairman, Mr. Brown was active also as Chairman of its Technical Forum and Membership Committee. He was the author of numerous technical papers in the trade press and the Society's *Transactions*, his last paper being "Application Data for Downlighting Equipment" presented at the I.E.S. National Technical Conference in 1948 at Boston, and published in the January, 1949, issue of ILLUMINATING ENGINEERING.

Mr. Brown joined Westinghouse at Pittsburgh in 1942 as a lighting design engineer in the Company's construction department. Two years later he transferred to the commercial engineering department of the Westinghouse Lamp Division in Bloomfield.

Prior to his Westinghouse career,

Mr. Brown was a lighting designer and commercial representative for the West Penn Power Company, public utility in the Pittsburgh district.

Born in McDonald, Pa., Mr. Brown was graduated from the Carnegie Institute of Technology in 1932 with the degree Bachelor of Science in Electrical Engineering. He was a member of Sigma Nu, college social fraternity.

N.A.E.D. Program to Aid Junior Achievement Movement

In the interest of fostering the work of the Junior Achievement movement, the National Association of Electrical Distributors has announced that it will sponsor several scholarships to be awarded to J.A. students who establish the best records in their electrical "companies," according to an announcement by Chas. G. Pyle, managing director. A highlight of this new program will be the selection of one of the award winners to be an honored guest at the annual Convention where he will be presented with a special plaque by the Association.

The N.A.E.D. Junior Achievement program was initiated at a meeting of a special committee under the chairmanship of F. E. Stern, Stern & Company, Hartford.

NEW MEMBERS

At the meeting of the Council held on October 13, 1949, the following were elected to membership:

BRITISH COLUMBIA SECTION

Associate Member:

Doherty, Thomas H., British Columbia Electric Railway Co., Vancouver, B. C., Canada.

CAROLINAS CHAPTER

Member:

Phillips, C. Harry, The Miller Co., Meriden, Conn.

Associate Members:

Kraybill, Edward K., Duke University College of Engineering, Durham, N. C.

Logan, John P. General Supply Co., Inc., Winston-Salem, N. C.

CAPITAL SECTION

Associate Member:

Ross, Spencer, 3105 Chesapeake St., N. W., Washington, D. C.

CENTRAL NEW YORK CHAPTER

Associate Member:

Sweetland, L. La Rue, Jr., New York State Electric & Gas Corp., Elmira, N. Y.

CHICAGO SECTION

Members:

Anderson, Jesse C., Westinghouse Electric Supply Co., Chicago, Ill.

Hultgren, Rudolph, Chicago Electrode Laboratories, Inc., St. Charles, Ill.

Associate Members:

Besal, R. J., Steber Mfg. Co., Broadview, Ill.

Ferman, L., Commonwealth Edison Co., Chicago, Ill.

Hall, Richard M., Electric Supply Corp., Chicago, Ill.

Horner, Robert Hill, The F. W. Wakefield Brass Co., Chicago, Ill.

Markstahler, Leonard H., Appleton Electric Co., Goodrich Division, Chicago, Ill.

Morrison, D. F., Commonwealth Edison Co., Chicago, Ill.

Randle, L. Vernon, University of Chicago, Chicago, Ill.

Riordan, John J., Commonwealth Edison Co., Chicago, Ill.

Rosenberg, Max, Leader Electric Corp., Chicago, Ill.

White, W. A., 26 N. Mayfield, Chicago 44, Ill.

Student Member:

Russell, Anson, H., University of Illinois, Urbana, Ill.

CLEVELAND SECTION

Associate Members:

Clark, Robert W., Jr., General Electric Co., Cleveland, Ohio

Graff, William Fred, Westlake, Ohio

Kosser, A. S., Phil Mar Corp., Cleveland, Ohio

Ryan, Paul T., Cleveland Electric Illuminating Co., Cleveland, Ohio

Tuttle, James W., General Electric Co., Cleveland, Ohio

Varner, Don F., Toledo Edison Co., Toledo, Ohio

CONNECTICUT SECTION

Associate Members:

Nelson, Alfred B., The Superior Electric Co., Bristol, Conn.

Shemitz, Norman S., Shemitz Electric Supply Co., New Haven, Conn.

CORNHUSKER CHAPTER

Associate Members:

Chenoweth, C. M., Tiney's Electric Co., Lincoln, Neb.

Rosenthal, Don E., Nebraska-Iowa Electrical Council, Omaha, Neb.

EASTERN PENNSYLVANIA CHAPTER

Associate Member:

Rodgers, Rolland W., Pennsylvania Power & Light Co., Pottsville, Pa.

FOREIGN NON-SECTION

Member:

Lascurain, M. M., Campos Elíseos 87, Col. Rincon del Bosque, Mexico City, D. F., Mexico

Associate Members:

Pello, L., Osram, Via Broggi 4, Milano, Italy

Rhodes, N., Bradford Corporation Gas Dept., Britannia House, Leeds Road, Bradford, Yorkshire, England

Sagrera, J. L., Electronica Iberica, S. A., Av. Jose, Antonio 10, Madrid, Spain

Taylor, J. L., Australian General Electric Pty., Ltd., 93 Clarence, Sydney, N.S.W., Australia

GEORGIA SECTION

Member:

Smith, Walter Sharp, Jr., Georgia Power Co., Augusta, Ga.

Associate Member:

Rutherford, J. Bennett, Loeb Hardware Co., Montgomery, Ala.

HEART OF AMERICA SECTION

Member:

Mann, Robert E., Mann & Company, Hutchinson, Kan.

Associate Member:

Barb, Earl C., Graybar Electric Co., Inc., Wichita, Kan.

MICHIGAN SECTION

Associate Members:

Guerin, George, Electrical Specialties Co., Detroit, Mich.

Harris, H. C., Giffels & Vallet, Inc., Detroit, Mich.

Hogan, Richard W., Giffels & Vallet, Inc., Detroit, Mich.

MILWAUKEE CHAPTER

Member:

Grosh, Howard W., Westinghouse Electric Corp., Milwaukee, Wis.

Associate Members:

Buge, Albie J., Buge Electric, West Allis, Wis.

Coconate, R. J., R. J. Coconate Electric, Cudahy, Wis.

MONTREAL SECTION

Member:

Rousselle, J. R., City of Montreal, Public Works Dept., Montreal, Que., Canada

Associate Members:

Beraha, Denyse, Montreal Daily Star, Montreal, Que., Canada

Lewis, H. H., Foundation Company of Canada, Ltd., Montreal, Que., Canada

McGovern, J. J., Northern Electric Co., Ltd., Montreal, Que., Canada

Student Member:

Mulvey, G. E., McGill University, Montreal, Que., Canada

MOTHER LODE CHAPTER

Associate Members:

Bursch, Charles W., Dr., Div. of Schoolhouse Planning, State of California, Sacramento, Calif.

Carlstroem, Philip, Sylvania Electric Products, Inc., Sacramento, Calif.

Horne, W. E., Div. of Architecture, State of California, Sacramento, Calif.

Lirsch, O. R., 2203 13th St., Sacramento, Calif.

Moore, Rex, Jr., 1517 19th St., Sacramento, Calif.

Patton, James C., Patton & Johnson Electric Co., Auburn, Calif.

NEW ENGLAND SECTION

Member:

Marchisio, Robert G., Sylvania Electric Products, Inc., Ipswich, Mass.

Associate Members:

Barber, Louis B., Henry L. Wolfers, Inc., Boston, Mass.

Barker, Joseph L., Boston Edison Co., Boston, Mass.

Bothwell, Harold H., Central Maine Power Co., Portland, Maine

Colleran, Edward J., Litecontrol Corp., Watertown, Mass.

Haas, Richard C., General Electric Co., Lynn, Mass.

Hulsizer, John C., General Electric Co., Lynn, Mass.

Lepore, Pasquale J., Bright Light Reflector Co., Inc., Boston, Mass.

McIntyre, H. Neel, General Electric Co., West Lynn, Mass.

Weeks, Arthur W. Champion Lamp Works, Lynn, Mass.

FLORIDA CHAPTER

Associate Members:

Dugger, Herbert A., Hughes Supply, Inc., Daytona Beach, Fla.

Wilkinson, John F., Florida Power & Light Co., Cocoa, Fla.

NEW ORLEANS SECTION

Associate Member:

Oglesby, Jimmie L., Hutson Colcock, 616 Baronne St., New Orleans, La.

NEW YORK SECTION

Members:

Busch, Carl R., Westinghouse Electric Corp., New York, N. Y.

Heffernan, James A., Public Service Electric & Gas Co., Newark, N. J.

Johnson, Laurence W., Westinghouse Electric International Co., New York, N. Y.

Associate Members:

Anderson, John R., Walter Kidde Constructors, Inc., New York, N. Y.

Holmes, Burton H., Reinhold Publishing Corp., New York, N. Y.

Holtzinger, James S., Long Island Lighting Co., Mineola, N. Y.

Nelson, Griffin T., Holophane Co., Inc., New York, N. Y.

Mahoney, Russell, 319 Forest St., Kearny, N. J.

Pray, Frank E., Sheffield Iron & Steel Co., New York, N. Y.

Prediger, Warren J., Benjamin Electric Mfg. Co., New York, N. Y.

Samuels, Joseph, Associated Group Optical Plan, Inc., New York, N. Y.

Stenson, Thomas F., Smitheraft Lighting Div., A. L. Smith Iron Co., New York, N. Y.

NORTHERN CALIFORNIA SECTION

Members:

Sawyier, Robert L., Jr., Pacific Gas & Electric Co., Oakland, Calif.

Vogel, Marcel J., Vogel Luminescence Corp., San Francisco, Calif.

Associate Members:

Schmitt, Hermann, Capital Co., San Francisco, Calif.

Thunen, George W., Fluorescent Fixtures of California, San Francisco, Calif.

Student Member:

Ambrosini, Arnold T., University of California, Berkeley, Calif.

OHIO VALLEY SECTION

Members:

Corning, R. V., General Electric Co., Cincinnati, Ohio

Schulte, R. J., General Electric Co., Cincinnati, Ohio

Associate Members:

De Noon, E. Ralph, Ohio Hardware Association, Columbus, Ohio

Bertke, D. G., Bertke Electric Co., Inc., Cincinnati, Ohio

Jobert, J. A., 309 Mariement Drive, Lexington #RR3, Ky.

Maxwell, Warner H., General Electric Supply Corp., Louisville, Ky.

Student Members:

Kessis, Theodore A., University of Cincinnati, Cincinnati, Ohio

Liepold, Richard E., University of Cincinnati, Cincinnati, Ohio

Mc Cann, Charles H., Jr., University of Cincinnati, Cincinnati, Ohio

OREGON SECTION

Associate Member:

White, J. P., North Coast Electric Co., Portland, Ore.

PHILADELPHIA SECTION

Member:

Richardson, Howard H., McHugh Electric Co., Wilmington, Del.

Associate Members:

Mellott, Elwood, Dept. of Public Safety, Wilmington, Del.

Puciato, Henry M., Henri Appliance Sales Co., Philadelphia, Pa.

PUGET SOUND SECTION

Member:

Gardener, H. A., Columbia Electric and Mfg. Co., Seattle, Wash.

Associate Members:

Cochran, G. Q., 111 N. Columbia, Olympia, Wash.

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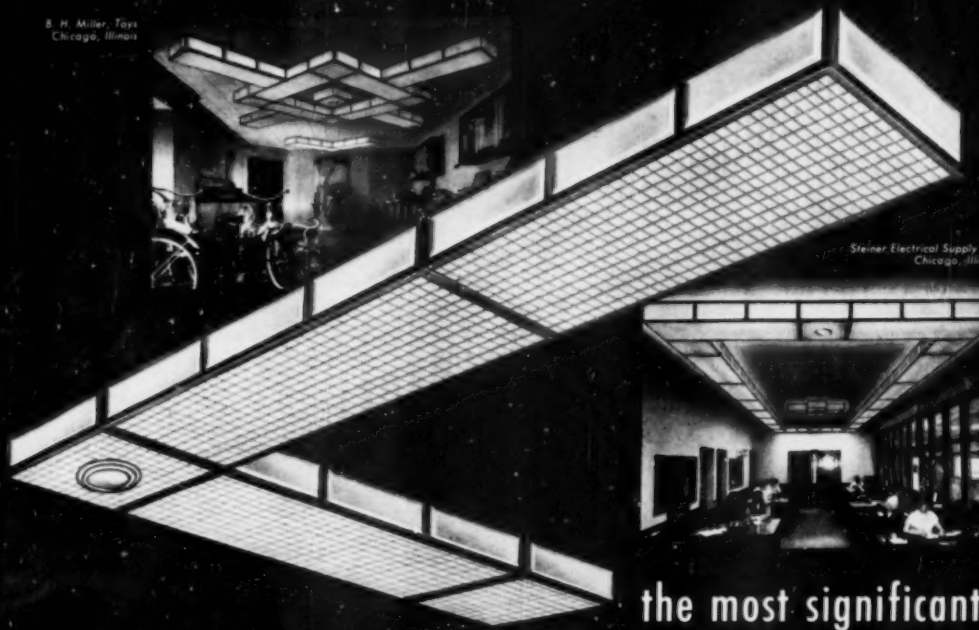

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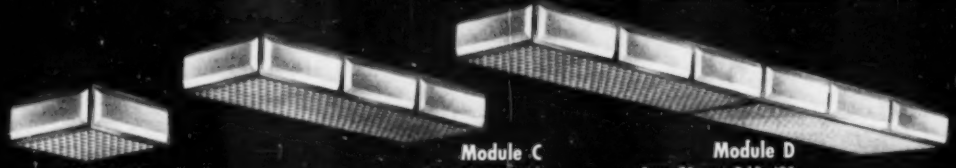

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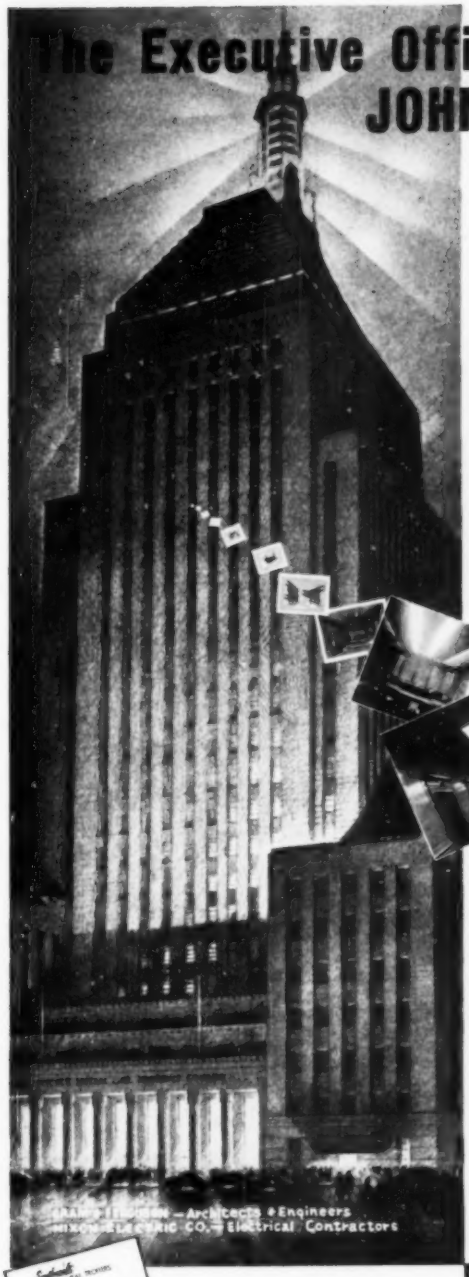

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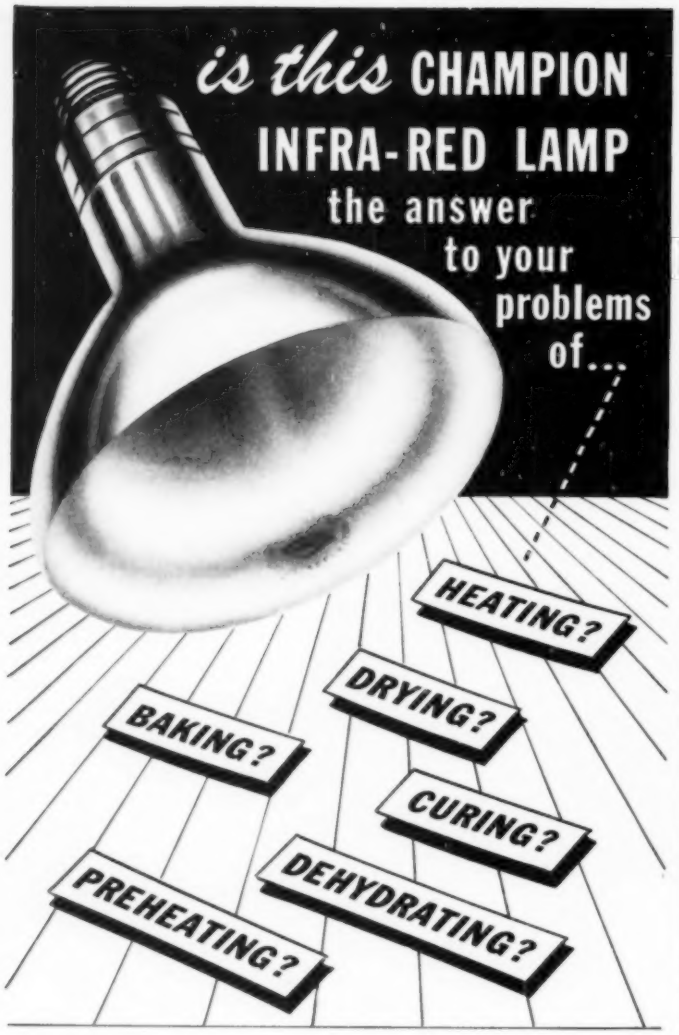

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for finest indirect lighting

lifetime beauty, efficiency

practically *no maintenance*

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HEATPROOF ALZAK** FINISH
is not discolored or affected by lamp heat.

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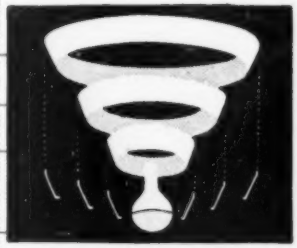
provides built-in reflector. Peak efficiency is *automatically* restored; when lamp is replaced, you have a new reflector.



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POWERSTAT Dimmers were the choice of management when plans were made for Long Beach, California's beautiful new Crest Theatre. The prototype of the theatre-of-the-future is a prefabricated unit designed for small towns and the export market. Only the most modern equipment was incorporated.

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ORIGINAL SOLID CORRUGATED GLASS

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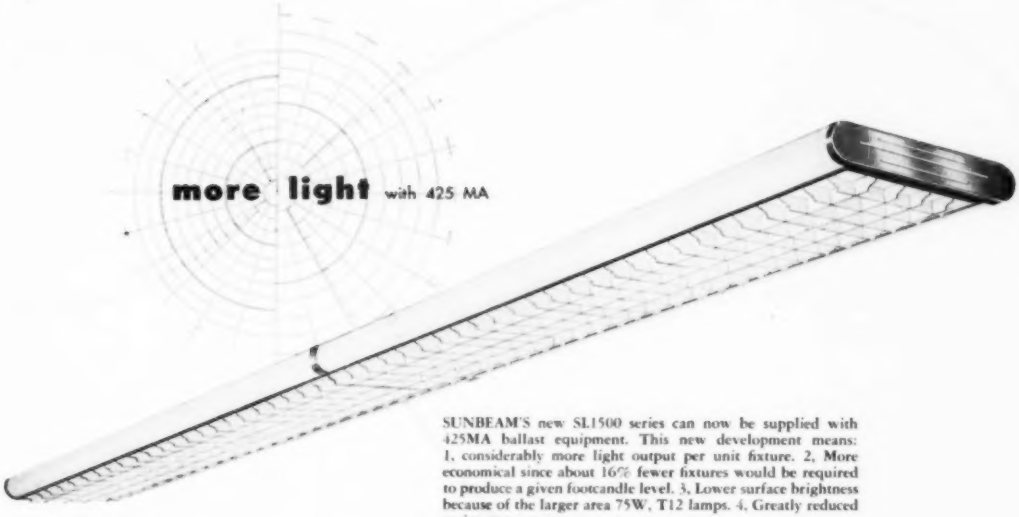

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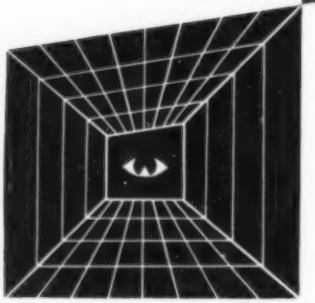

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THE miller COMPANY
SINCE 1914
ILLUMINATING DIVISION, MERIDEN, CONNECTICUT

ILLUMINATING DIVISION: Fluorescent, Incandescent, Mercury Lighting Equipment. HEATING PRODUCTS DIVISION: Domestic Oil Burners and Liquid Fuel Devices. ROLLING MILL DIVISION: Phosphor Bronze and Brass in Sheets, Strips and Rods.

Only FLEUR-O-LIER *gives ALL these advantages:*

★ Fleur-O-Lier Index System Rating

★ Photometric Data

★ Coefficients of Utilization Charts

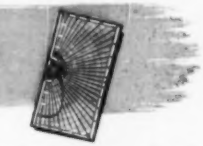
★ Certification

MORE AND MORE architects, utility lighting men and contractors are recommending Fleur-O-Lier labeled fixtures because only with Fleur-O-Lier certified fixtures do they get *all* "the facts of light" that enable them to get the most fixtures for their money.

★1

Every Fleur-O-Lier fixture is rated on the Fleur-O-Lier Index System to show its tested illuminating performance.

★2



Complete photometric data, as found by Electrical Testing Laboratories, Inc., is provided.

★3

Coefficients of utilization charts, compiled by Electrical Testing Laboratories, Inc., enable the buyer to select the most suitable fixture for his installation.

★4

Certification, backed by Electrical Testing Laboratories, Inc., tests, is the buyer's assurance that the fixtures were made to rigid specifications covering electrical and mechanical features.

Certified
CERTIFIED
in accordance with Test Requirements of Specifications of Fleur-O-Lier Manufacturers
ELECTRICAL TESTING LABORATORIES, INC.
NEW YORK N. Y.

Specifiers and buyers are now insisting, "Be sure the fixtures bear the Fleur-O-Lier label!"

FLEUR·O·LIER

Manufacturers

2116 Keith Building • Cleveland 15, Ohio

Fleur-O-Lier is not the name of an individual manufacturer, but of a group of fixtures made by leading manufacturers. Participation in the Fleur-O-Lier program is open to any manufacturer who complies with Fleur-O-Lier requirements.

NEW! FLUORESCENT Sun Lamps

A TOTALLY NEW APPROACH TO THE HUGE "SUN" MARKET

Here is a new business opportunity which offers immediate extra sales . . . and one with future sales potentials so favorable that, as yet, only the broad outlines can be sketched.

The Westinghouse fluorescent sun lamp makes possible, for the first time, a practical and economical means for bathing wide areas with beneficial ultraviolet rays. This means that everyone may now be offered all the Vitamin D-creating benefits of ultraviolet . . . right while they work or play indoors.

Compared with the conventional bulb-type sun lamp, this new fluorescent lamp is cool in operation, and has five times the output and ten times the life. In addition, it costs less to buy, less to run, and fits standard fluorescent fixtures. Consequently, it is practical for homes, factories, schools, offices, bowling alleys, and animal husbandry applications—to name just a few. Besides being ideal for wide-area application, it is excellent for suntanning. This advantage makes it especially attractive for use in hospitals, barber and beauty shops, solaria, gymnasia, and even home bathrooms.

Unquestionably, there is a vastly broadened market opened up by this new fluorescent sun lamp. Cash in on the opportunity! Write for further details. Address: Lamp Division, Westinghouse Electric Corporation, Bloomfield, N. J.

TECHNICAL DATA

	20-WATT LAMP	40-WATT LAMP
Bulb diameter	1½"	1½"
Lamp Length	24"	48"
Operating amperes	0.36	0.415
Operating volts	60	106
Base	Medium Bipin	Medium Bipin
List Price	$4.50	$7.00

Rated Avg. Life: 2500 hours at 3 hours per start
4000 hours at 6 hours per start
5000 applications at 15 minutes per start

YOU CAN BE SURE...IF IT'S Westinghouse